Energy Research and Development Division
FINAL PROJECT REPORT

IMPACTS OF SHORT-TERM, INTERBASIN, AND INTERPOLLUTANT CREDIT TRADING ON AIR QUALITY AND CREDIT PRICES

Prepared for: California Energy Commission

Prepared by: TIAX LLC

JULY 2013

CEC-500-2013-025

Prepared by:

Primary Author(s):
Jennifer Pont, TIAX LLC
Josh Margolis, Cantor CO2e
Malcolm Weiss, Hunton & Williams LLP
Nancy Brown, Lawrence Berkeley National Laboratory

Contract Number: MAQ-07-02

Prepared for:

California Energy Commission

Guido Franco
Team Lead

Marla Mueller
Project Manager

Linda Spiegel
Office Manager
Energy Generation Research Office

Laurie ten Hope
Deputy Director
ENERGY RESEARCH AND DEVELOPMENT DIVISION

Robert P. Oglesby
Executive Director

ACKNOWLEDGEMENTS

This project was managed by TIAX LLC with significant contributions from subcontractors CantorCO2e and Hunton & Williams LLP and researchers at Lawrence Berkeley National Laboratory.

PREFACE

The California Energy Commission Energy Research and Development Division supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The Energy Research and Development Division conducts public interest research, development, and demonstration (RD&D) projects to benefit California.

The Energy Research and Development Division strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

Energy Research and Development Division funding efforts are focused on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy Innovations Small Grants
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

Impacts of Short-Term, Interbasin, and Interpollutant Credit Trading on Air Quality and Credit Prices is the final report for the CIEE Emission Reduction Credits Trading Impacts project, Subcontract Number MAQ-07-02, conducted by TIAX LLC. The The information from this project contributes to Energy Research and Development Division's Energy-Related Environmental Research Program.

For more information about the Energy Research and Development Division, please visit the Energy Commission's website at www.energy.ca.gov/research/ or contact the Energy Commission at 916-327-1551.

ABSTRACT

Installation of a significant quantity of electric power generating capacity is needed in California over the next 10 years to replace aging steam generators that have once through cooling systems and to address forecasted increases in demand. Depending on location, installation of new power plants requires surrender of emission reduction credits to the local air district. In many air districts where new additional power is needed, the emission reduction credit market is constrained. In certain instances, credits can be purchased from other areas to place a power plant in a credit-constrained area. However, strict regulations ensure that these interbasin trades do not increase air pollutants. Some of these regulations are broadly restrictive because it is difficult to determine what the air quality impact may be; therefore, safety measures are built into the regulations to ensure public health is maintained.

Modeling techniques in development allow modeling over many weeks or months and capture all relevant types of meteorological conditions. This may increase models' abilities to identify environmentally benign trades more accurately. Several key aspects of interbasin trading in California were explored, including (1) laws governing the credit trading restrictions to determine the ability of state and local government to allow such trades; (2) the current state of the credit market and economics, to determine the likelihood of trades occurring if regulations were to be modified; and (3) the ability of models to assess the environmental impact of such trades.

Research conclusions indicate that the regulatory structure and market mechanisms could accommodate interbasin and short-term trades and may alleviate some current constraints. However, the complexity of pollutant formation underscores the need for an accurate inventory, inventory projections, and improved tools and protocols. These trades would most likely require intensive modeling throughout the life of the credit to ensure achievement of environmental benefits. Several recommendations for improvements to the system and opportunities for trading structures are highlighted.

Keywords: Interbasin, interpollutant, emission reduction credit, ERC, pollutant credit trading

Please use the following citation for this report:

Pont, J. (TIAX LLC), J. Margolis, (CantorCO2e), M. Weiss (Hunton & Williams LLP), and Nancy Brown (Lawrence Berkeley National Laboratory). 201e. ***Impacts of Short-Term, Interbasin, and Interpollutant Credit Trading on Air Quality and Credit Prices.*** California Energy Commission. Publication Number: CEC-500-2013-025

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

Introduction

The California Energy Commission projects that the state's electric power consumption will grow by 13 percent from 2008 to 2018, with coincident peak electricity demand increasing by almost 10 gigawatts (GW). To meet this demand, many new power plants will need to be installed throughout the state. To obtain a construction permit, proposed power plants must offset their emissions by obtaining emission reduction credits (either through shutdowns on-site or through market purchases) and surrendering them to the local air district. At present, there are insufficient emission reduction credits available to site a new natural gas combined cycle 500 megawatt (MW) plant in several of the larger air districts. The problem is the most acute in the South Coast Air Quality Management District. For example, at the time of this report (2010), there are seven pending power plant projects that are unable to secure particulate matter credits.

Purpose

This project sought to determine whether more flexible emission reduction credit trading rules would improve market conditions without adversely affecting progress toward attaining ambient air quality standards. Specifically, this project investigates the potential of interbasin (between two air basins), interpollutant (between two pollutants), and short-term (hours-months) trading within California.

Project Objectives

This project's specific objectives were to:

- Review the laws governing trading of emission reduction credits to determine the scope, limitations, and precedence of implementing interbasin and short-term credit trades.
- Review the market mechanisms and prices to determine under what conditions interbasin and short-term credits would be traded within California if the regulations allowed.
- Using a case study, explore whether some trades may be environmentally benign under alternate trading scenarios not currently allowed.
- Evaluate the ability of ozone models to provide sufficient accuracy of the air quality impacts of such trades.

Project Outcomes

The review of regulations show that California state-level and local air district rules regarding emission offsets are more stringent than federal rules. The air districts rarely allow interpollutant and interbasin credit trading. Three regions were analyzed in the market analysis. Results showed that interpollutant offsets for the South Coast Air Quality Management District particulate matter (PM_{10}) may provide some relief to the PM_{10} market constraints if low offset ratios are allowed. They also showed that interbasin trades from the San Joaquin Valley Air Pollution Control District to the Sacramento Metropolitan Air Quality Management District may provide some price relief to the nitrogen oxides (NOx) and volatile organic compounds (VOC) markets. While short-term trading would clearly be helpful to power plant developers, it was not possible to quantify the availability of short-term emission reduction credits within the budget constraints of the project.

Air quality modeling was conducted for six potential interbasin trades. The simulations showed that ozone increases are small, approximately 1 part per billion (ppb) per 500 MW added capacity. Impacts of less than 1 ppb are considered below the resolution of the model and are not reported.

Finally, the ambient impact of interpollutant trading depends highly upon local ozone formation characteristics (such as a NOx disbenefit or NOx benefit regime). (In a NO_X disbenefit regime removing NO_X emissions will increase ozone, while adding NO_X emissions will decrease ozone. In an NO_X benefit regime, removing NO_X emissions will reduce ozone, and adding NO_X emissions will increase ozone.) Ozone characteristics change significantly in time and location, due to different weather patterns and relative emissions releases of NOx and VOC. This is an important variable to understand that will affect the impact of a trade over space and time.

Conclusions

Based on the market analysis of possible price and availability of emission reduction credits under different trading constructs, it appears that allowing some interpollutant and short-term trades within California are theoretically possible. The market analysis indicates that more flexible trading mechanisms, such as interpollutant and interbasin trades, can provide power plants access to emission reduction credits that were unavailable and/or reduce emission reduction credit prices.

Generally, because of different NO_x sensitivity regimes, trading among these locations almost always leads to very small, almost undetectable, increases in ozone somewhere. Since most of the region experiences ozone levels above the 2005 state standard of 70 ppb, any ozone increases must be avoided. However, from the limited case study conducted, it appears that some interbasin and short-term trades that are not currently allowed would not adversely impact ozone levels.

While the modeling proved to be effective at identifying maximum impacts of specific scenarios, it was unable to capture the impacts of small variations in typical trades. Moreover, the modeling exercise emphasized the importance of a more accurate and up-to-date temporally and spatially resolved emissions inventory, due to the sensitivity of the nonlinear reactions of the precursor pollutants. Equally needed are dependable future inventory estimates for evaluating continued air quality impacts throughout the life of the trade. Without improvements to the modeling and emissions inputs, the ability for a more refined approach to analyzing air quality impacts of trades, such as what was investigated here, is limited.

Recommendations

The complexity of ozone formation and the sensitivity of accurate inputs require improvements to the modeling system before accurate analysis of environmental impacts is feasible. A logical next step would be to conduct a comprehensive modeling exercise that would expand the modeling on interbasin trading of ozone precursors and explore interbasin trading of PM and its precursors. This type of study would support detailing the benefits and limitations of the trading scenarios on air quality impacts, precursor impacts, and the sensitivity to various modeling inputs. Only an air quality modeling exercise and protocol of this caliber would provide air districts and other policy makers enough information to support explicit evaluations of interbasin trading offset ratios, rather than resorting to conservatively high ratios in the absence of data. Specifically, the expanded modeling exercise would:

- **Investigate multiple trades during multiple occasions that are representative of an ozone season.** This is especially important for areas that can have different NOx benefit/disbenefit regimes, depending upon the meteorology, and this effect will have to be viewed over the range of meteorological conditions in the area.
- **Use accurate and current inventory data, and consider the range of projected inventory data throughout the lifetime of the credit.** This is especially important with large and uncertain reductions in NOx emissions anticipated from the heavy-duty truck and off-road programs.
- **Evaluate the potential impact of VOC on ozone attainment.** In this case study, VOC emissions were so small, compared to the entire inventory, that impacts from the trades were not evaluated. However, other scenarios would need to be evaluated to identify conditions where VOC is a concern.
- **Include the impacts of emissions of fine particulate and its precursors on PM attainment.**
- **Expand the analysis from Central and Northern California to also include Southern California.**
- **Develop a peer-reviewed protocol for this procedure.**

Finally, current short-term credits have a finite life and are therefore risky to power plant developers. Research into a mechanism for emission credits to be denominated in tons per year, but for only certain hours of the day, is recommended as a potential solution.

Benefits to California

If the recommended additional research on ozone and PM modeling is conducted and shows that more flexible interbasin and interpollutant trading does not adversely affect attainment of any criteria pollutants, then conceivably emission reduction credits from nonadjacent air basins could be traded. Further, assuming that state or district rules governing the use of emission reduction credits were modified based on the modeling results, emission reduction credit supplies in currently constrained markets would be significantly augmented. More availability of emission reduction credits would result in lower prices for those credits, which would facilitate quicker installation of new, cleaner generation, and result in less expensive power generation in California.

CHAPTER 1: Introduction

1.1 Background

New major stationary sources of emissions, including fossil fuel-powered electricity generators, are required to undergo New Source Review (NSR) permitting prior to construction. New Source Review requirements scale inversely with local air quality. In areas that attain all of the criteria pollutant ambient air quality standards, the new source is required to control emissions through installation of "Best Available Control Technology" (BACT) and to perform modeling to ensure that it will not cause a violation of the air quality standards.

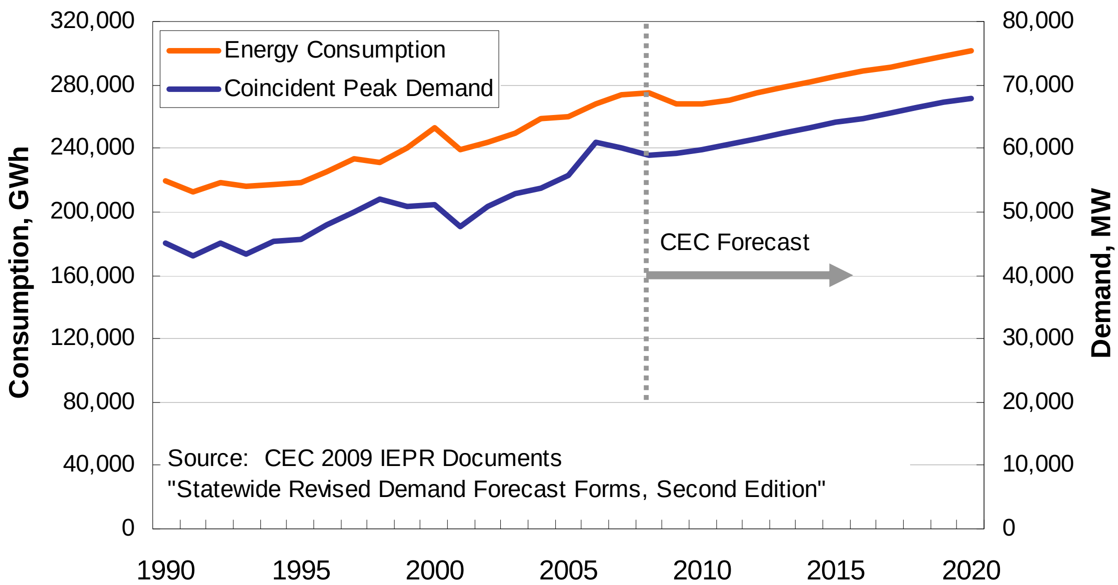
If a new source is to be located in an area that does not attain the ambient air quality standards for any of the criteria pollutants, it must install "Lowest Achievable Emission Rate" (LAER) technology for each non-attainment pollutant. In addition, the emissions of each non-attainment pollutant must be offset by acquisition and surrender of emission reduction credits (ERCs). Emission reduction credits are a perpetual right to emit a certain pollutant and are denominated in mass per unit time. In general, more ERCs must be surrendered than the emissions from the new source. If the source is to be located in an area that is far from attaining the ambient standard, then an offset ratio of 1.5 or higher may be imposed (50 percent more ERCs than emissions).

In issuing ERCs, the local air district must ensure that the ERCs created are permanent, quantifiable, enforceable, and surplus. Moreover, the quantity of ERCs created is equal to the recent actual emissions, not the allowable/permitted emissions. Because plants that are shut down typically experience low utilization for their last several years of operation, the number of ERCs created by the shutdown is much lower than the number of ERCs acquired when the plant was originally permitted. Because ERCs are issued based on recent actual emissions, and because offset ratios are greater than 1:1, the supply of ERCs is always decreasing.

The intent of the offset requirement in nonattainment areas is to gradually diminish the supply of ERCs until the area attains the ambient standards. However, a growing population needs new electricity generation sources to serve its growing needs. Over time, more and more sources are added, but since they are generally much cleaner than their older predecessors, fewer ERCs are needed. At some point, however, the new sources are so clean that it is not possible to reduce emission rates any further. Similarly, the number of ERCs in the system slowly decreases through high offset ratios at the time of permitting and through reduced utilization of sources prior to their retirement. Therefore, eventually there are not enough ERCs available to allow clean new sources to be permitted in the area, despite a need for increased services presented by a growing population.

As shown in Figure 1, the California Energy Commission predicts that California's electricity consumption will grow by 13 percent from 2008 to 2018, with coincident peak electricity demand increasing by almost 10 gigawatts (GW). While some of the growth in energy demand will be met through renewables, the intermittency issues associated with wind and hydro generation require a significant portion of the demand to be met with natural gas-fired power plants. Permitting of these new power plants will require ERCs.

Figure 1. California Energy Demand Forecast

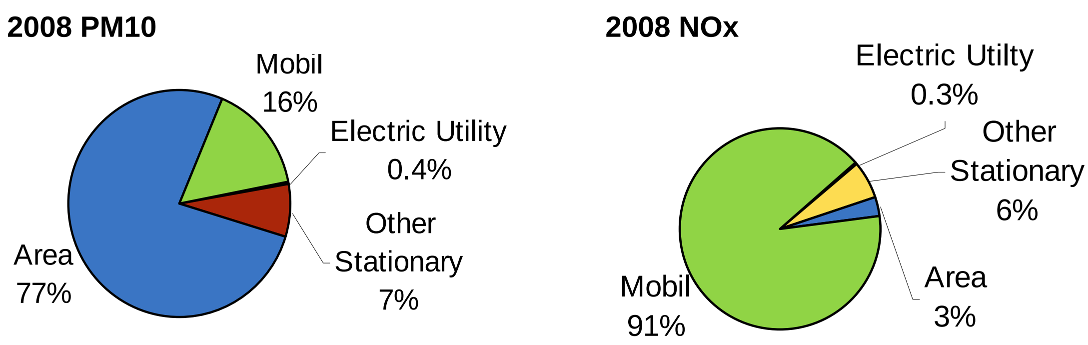


As of 2010, there were not sufficient particulate matter (PM) or nitrogen oxides (NOx) ERCs to allow a new 500 megawatt (MW) natural-gas combined-cycle plant to be installed in the Sacramento, San Diego, or South Coast air districts. For example, in the South Coast Air Quality Management District (SCAQMD), the supply of PM_{10} emission reduction credits was not sufficient to allow seven needed power plant projects to move forward. (PM_{10} is particulate matter 10 microns or less in size.) These new plants are intended to replace old steam generators that use once through cooling. The replacement is essential for California to achieve its greenhouse gas (GHG) emission goals and to eliminate the impacts of once through cooling systems on marine life. In effect, the PM_{10} offset requirement places more value on very small reductions in PM_{10} emissions over significant GHG and marine life benefits. From a health perspective this may be appropriate.

To put this into perspective, Figure 2 illustrates the contribution of different types of sources to the South Coast Air Quality Management District's PM_{10} and NOx emissions. Although the electric utility category represents less than 0.5 percent of the district's NOx and PM_{10} emissions, new sources are not allowed to be added in some areas because of a lack of ERCs.

Given that there is projected need for significant levels of new power generating capacity in California, and the simultaneous constriction of ERC markets, this study sought to determine if innovative credit trading policies that improve ERC markets and not adversely affect air quality could be implemented.

Figure 2. SCAQMD 2008 PM10 and NOx Emission Inventory



Source: ARB 2009.

1.2 Approach

This study's objective was to explore the feasibility of adding flexibility to existing ERC use rules while considering both environmental and market constraints. Three types of flexible trades were considered: interbasin, interpollutant, and short-term. The study was managed by TIAX LLC with major contributions from Lawrence Berkeley National Laboratory (LBNL) and CantorCO2e. TIAX provided a summary of federal, state, and local rules and guidance governing ERC use. The air quality modeling team from LBNL conducted a limited feasibility study focused on the impacts of NOx interbasin trading on ozone between Northern and Central California. It is important to point out that in addition to NOx, power plants emit small amounts of volatile organic compounds (VOC) and PM_{10}. The impacts of these pollutants on air quality were not considered. Nor was the secondary formation of PM_{10} from NOx and VOC. By reviewing past trades, request for trades, and market constraints, CantorCO2e evaluated the economic impact of interbasin and interpollutant trading for the locations and pollutants that currently have shortages: PM_{10} supplies in the SCAQMD, NOx supplies in the Sacramento Metropolitan Air Quality Management District (SMAQMD), and NOx and VOC supplies in the San Diego Air Pollution Control District (APCD).

The project was structured with the following main tasks, each described in more detail in the following sections:

1. **Review of ERC Rules**

   The objective of this task was to compile all of the environmental regulations and policy statements governing the use of short-term, interbasin, and interpollutant ERCs at the federal, state, and California air district levels. The state and local requirements were compared to federal requirements to determine if any provisions of state and local rules are more stringent and/or less flexible than what is required by the Federal Clean Air Act (CAA).

2. **Air Quality Modeling Analysis**

   The objective of this task was to evaluate the environmental impacts of the example trades defined in the previous task. This task was not intended to consider all of the possible environmental impacts, but rather to look specifically at the impacts on local ozone formation from changes in NOx emissions resulting from the example trades. The initial thinking was to restrict the example trades to comply with federal requirements. Because this limitation limited the number of example trades that made sense to evaluate, the approach was modified so that it allowed example trades to be examined even if they did not adhere to state, local, and federal requirements. The results are intended simply to inform our understanding of whether the current restrictions on the use of NOx emission reduction credits make sense from an ozone standpoint.

3. **Market Analysis**

   The objective of this task was to determine the impact of introducing more flexible trading options on ERC availability and price.

4. **Synthesis of Results**

   The objective of this task was to synthesize the results of the foregoing analyses and determine under what conditions flexible trades improve market conditions and do not harm the environment, and to provide recommendations on how the ERC trading system in California could be improved to facilitate these types of trades.

CHAPTER 2:
Review of ERC Rules

In this analysis the federal ERC use requirements were defined and compared to the requirements established by the State of California and five air districts:

- Bay Area Air Quality Management District (BAAQMD)
- Sacramento Metropolitan Air Quality Management District (SMAQMD)
- San Joaquin Valley Air Pollution Control District (SJVAPCD)
- South Coast Air Quality Management District (SCAQMD)
- San Diego Air Pollution Control District (SDAPCD)

The rules were evaluated based on four criteria: stringency, interbasin provisions, interpollutant trading provisions, and short-term trading provisions.

2.1 Summary of Air Quality Standards and Attainment Status

Local rules governing the use and creation of ERCs and the actual approval of ERC applications and trades depend to a large extent on local air quality and are materially affected by agency and public perceptions about air quality and trading of emissions.

Local air quality is determined by comparing ambient concentrations of pollutants to standards intended to protect public health. The federal government sets national ambient air quality standards (NAAQS) for each criteria pollutant: ozone, PM_{10}, $PM_{2.5}$, carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and lead. The Federal Clean Air Act allows states to set their own ambient standards, but they must be at least as stringent as the federal standards. Table 1 provides a summary of current national (federal) and State (California) ambient air quality standards.

Table 1. Summary of State and Federal Ambient Air Quality Standards

Pollutant	Averaging Time	California Standards	Federal Standards
Ozone	1 Hour 8 Hour	0.09 ppm 0.07 ppm	Revoked 0.075
PM10	24 Hour Annual Arithmetic Mean	50 $\mu g/m^3$ 20 $\mu g/m^3$	150 $\mu g/m^3$ 50 $\mu g/m^3$
PM2.5	24 Hour Annual Arithmetic Mean	n/a 12 $\mu g/m^3$	35 $\mu g/m^3$ 15 $\mu g/m^3$
CO	1 Hour 8 Hour 8 Hour (Lake Tahoe)	20 ppm 9 ppm 6 ppm	35 ppm 9 ppm n/a
NO_2	1 Hour Annual Arithmetic Mean	0.18 ppm 0.03 ppm	n/a 0.053 ppm
SO_2	1 Hour 3 Hour 24 Hour Annual Arithmetic Mean	0.25 ppm n/a 0.04 ppm n/a	n/a 0.5 ppm (secondary) 0.14 ppm 0.03 ppm
Lead	30 Day Average Calendar Quarter	1.5 $\mu g/m^3$ n/a	n/a 1.5 $\mu g/m^3$

Except for lead, California standards are not to be exceeded. Lead concentrations must be less than standard.

National standards are not to be exceeded more than once per year EXCEPT:

-- Ozone is attained when the 4th highest 8-hr concetration in a year, averaged over three years is equal or less than the standard.

-- The 24 hr PM10 standard is attained when the expected number of days per year with a 24 hr avg concentration above 150 mug/m3 is one or less.

-- The 24 hr PM2.5 standard is attained when 98% of the daily concentrations, averaged over 3 years are equal to or less than the standard.

If ambient air sampling indicates that one of the standards is exceeded, the area may be deemed "nonattainment" [1] for that pollutant. Nonattainment areas are further classified as *marginal, moderate, serious, severe,* or *extreme*, depending on the relative concentration of pollutants in the air (as determined through the use of monitors).

Under Section 110 of the Clean Air Act, states are required to develop State Implementation Plans (SIPs) demonstrating how they will implement, maintain, and enforce the NAAQS. If an area is designated nonattainment for a pollutant, the SIP must show how emissions of that pollutant will be reduced so that the NAAQS will be attained within that area and within stated time frames.

[1] A *Nonattainment* classification happens after the exceedance occurs the requisite number of times, a finding is made by the U.S. Environmental Protection Agency (U.S. EPA), and a federal register notice is published.

Table 2 and Figure 3 show federal ozone nonattainment areas within California. Much of the state fails to attain the federal ozone standard. Tables 3 and 4 show federal nonattainment areas for PM_{10} and $PM_{2.5}$. Much of the state failed to attain the federal PM_{10} standard as well. Only the San Joaquin Valley and South Coast basins have not attained the federal $PM_{2.5}$ standard.

Table 2. Federal 8-hr Ozone Nonattainment Areas

Area Name	Design Value, ppm	Status	Counties in Federal 8 hr Ozone Nonattainment Area
Central Mountain	0.091	Basic	Amador, Calaveras
Chico	0.089	Basic	Butte
Imperial County	0.087	Marginal	Imperial
Eastern Kern	0.098	Basic	Kern (eastern portion)
South Coast Air Basin	0.131	Severe 17	Orange and portions of Los Angeles (SW), Riverside (eastern), San Bernardino (SW corner)
Western Mojave	0.106	Moderate	Parts of Los Angeles (NW) and San Bernardino (central portion)
Southern Mountain	0.091	Basic	Mariposa, Tuolumne
Nevada County	0.098	Basic	Western portion of Nevada
Coachella Valley	0.108	Serious	Middle portion of Riverside
Sacramento Metro	0.107	Serious	Sacramento and Yolo, most of El Dorado and Placer, parts of Solano (NE corner), Sutter (southern tip)
San Diego	0.093	Basic	Part of San Diego
San Francisco Bay Area	0.086	Marginal	Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, parts of Solano (SW), Sonoma (southern)
San Joaquin Valley	0.115	Serious	Fresno, Kings, Madera, Merced, San Joaquin, Stanislaus, Tulare, west portion of Kern
Sutter Buttes	0.088	Basic	Northern portion of Sutter
Ventura County	0.095	Moderate*	All of Ventura county except the islands

* Proposed serious

Source: U.S. EPA Office of Air Quality Planning and Standards

Figure 3. Map of Attainment Status for Federal Ozone Standard as of 2006

**Nonattainment* as defined under subpart 1

Source: California Air Resources Board.

Table 3. Federal PM_{10} Nonattainment Areas

Area Name	Status	Counties in Federal PM10 Nonattainment Area
Coachella Valley	Serious	Part of Riverside
Coso Junction	Moderate	Part of Inyo
Imperial Valley	Serious	Part of Imperial Valley
South Coast Air Basin	Serious	Orange and parts of Los Angeles, Riverside, San Bernardino
Mammoth Lake	Moderate	Part of Mono
Mono Basin	Moderate	Part of Mono
Owens Valley	Serious	Part of Inyo
Sacramento County	Moderate	Sacramento
San Bernardino County	Moderate	Part of San Bernardino
Trona	Moderate	Part of San Bernardino

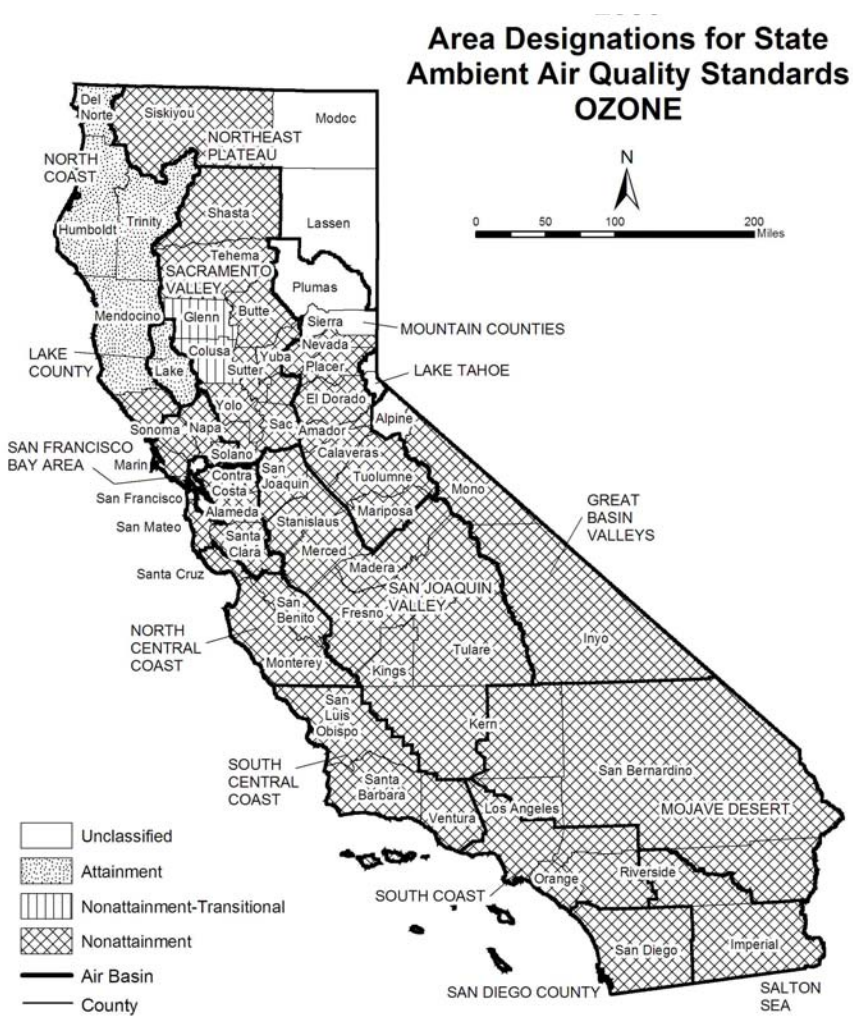
Note: San Joaquin attained Sept 2007

Table 4. Federal $PM_{2.5}$ Nonattainment Areas

Area Name	Status	Counties in Federal PM2.5 Nonattainment Area
South Coast Air Basin	Serious	Orange and parts of Los Angeles, Riverside, San Bernardino
San Joaquin Valley	Serious	Fresno, Kings, Madera, Merced, San Joaquin, Stanislaus, Tulare, part of Kern

Figure 4 and Table 5 indicate attainment designations for the California ambient standards. As can be seen, nearly the entire state fails to attain the state ozone and PM_{10} standards. Much of the state fails to attain the $PM_{2.5}$ standard.

Figure 4. Map of Attainment status for State Ozone Standard as of 2006



(Source: California Air Resources Board)

Table 5. Summary of Attainment Status for California Ambient Standards

Air Basin	Area Included	Attainment Status		
		Ozone	PM10	PM2.5
Great Basin Valleys	Alpine County	U	N	U
	Inyo County	N-Moderate	N	U
	Mono County	N-Moderate	N	U
Lake County	Entire Air Basin	A	A	A
Lake Tahoe	Entire Air Basin	U	N	A
Mojave Desert	Entire Air Basin	N-Serious	N	U1
Mountain Counties	Amador County	N-Serious	U	U
	Calaveras County	N-Serious	N	U
	Eldorado County	N-Serious	N	U
	Yosemite Nat'l Park	N-Serious	N	U
	Nevada County	N-Serious	N	U
	Placer County	N-Serious	N	U
	Plumas County	U	N	U3
	Sierra County	U	N	U
	Tuolumne County	N-Moderate	U	U
North Central Coast	Entire Air Basin	N-Moderate	N	N
Northeast Plateau	Lassen County	U	N	U
	Modoc County	U	N	U
	Siskiyou County	N-Moderate	A	U
Sacramento Valley	Butte County	N-Moderate	N	N
	Colusa County	NA-T	N	U
	Glenn County	NA-T	N	U
	Placer County	N-Serious	N	N
	Sacramento Cty	N-Serious	N	N
	Shasta County	N-Serious	N	U
	Sutter/Yuba Cties	N-Moderate	N	U
	Tehama County	N-Moderate	N	U
	Yolo/Solano Cties	N-Moderate	N	U
Salton Sea	Entire Air Basin	N-Serious	N	U2
San Diego	Entire Air Basin	N-Moderate	N	N
SF Bay Area	Entire Air Basin	N-Moderate	N	N
San Joaquin Valley	Entire Air Basin	N-Serious	N	N
South Central Coast	San Luis Obispo Cty	N-Moderate	N	A
	Santa Barbara Cty	N-Moderate	N	U
	Ventura County	N-Moderate	N	N
South Coast	Entire Air Basin	N-Severe	N	N

U=Unclassified, A=Attainment, N=Nonattainment, NA-T=N-Transitional

U1 = unclassfied except for a portion of San Bernardino cty that is N

U2 = unclassified except the City of Calexico that is N

U3 = unclassified except town of Portola is N

2.2 ERC Use Requirements at the Federal Level

At the federal level the rules governing creation and use of ERCs are found in the CAA. The provisions relating to ERCs and offsets[2] are codified in the Code of Federal Regulation (CFR) Title 40 Part 51 Subpart I: Review of New Sources and Modifications. Specifically, 40 CFR §51.165 stipulates that emission offsets are required for ***new major sources*** and for ***major modifications*** at existing sources if the net emissions increases of nonattainment pollutants are ***significant*** after the modification.

Major source[3] is defined as any source that emits or has the potential to emit 100 tons per year (tpy) or more of any criteria pollutant or:

- 50 tpy of VOC or NOx in serious ozone nonattainment areas
- 25 tpy of VOC or NOx in severe ozone nonattainment areas
- 10 tpy of VOC or NOx in extreme ozone nonattainment areas
- 70 tpy PM_{10} in serious PM_{10} nonattainment areas

Major modifications are defined as **Significant**[4] for each criteria pollutant (or precursors) as follows:

- CO: 100 tpy CO
- NO_2: 40 tpy NOx
- SO_2: 40 tpy SO_2
- Ozone: 40 tpy of VOC or NOx
- Lead: 0.6 tpy of lead
- PM_{10}: 15 tpy PM_{10}

In nonattainment areas, new and modified major sources with significant emissions (or significant emissions increases for modified sources) must install lowest achievable emission rate (LAER) technology for each significant nonattainment pollutant. In addition, for each nonattainment criteria pollutant (or their precursors) emitted at or above significant levels, the emissions (or emissions increase for modified sources) must be offset with ERCs. For example, if a new source will emit 20 tons/yr of NOx in an ozone nonattainment area, the source must install LAER and obtain and surrender 20 tons/yr of NOx ERCs. In ozone nonattainment areas, significant VOC and NOx emissions must be offset at the ratios indicated in Table 6. Note that

---

[2] CAA Title I, Part D, SubPart 1: Nonattainment Areas in General and SubPart 2: Additional Provisions for Ozone Nonattainment Areas

[3] 40 CFR §51.165 (a)(1)(iv)(A)

[4] 40 CFR §51.165 (a)(1)(x)(A)

these are federal offset ratios; states and local air districts may modify these as long as they are at least as stringent as the federal requirement.

Table 6. Federal Requirements for Offset Ratios[5]

Ozone Nonattainment Status	Offset Ratios for NOx and VOC
Marginal	1.1:1
Moderate	1.15:1
Serious	1.2:1
Severe	1.3:1 (may be 1.2:1 if all existing major sources have installed BACT for NOx and VOC)
Extreme	1.5:1 (may be 1.2:1 if all existing major sources have installed BACT for NOx and VOC)

Appendix S to 40 CFR Part 51, Emission Offset Interpretative Ruling, provides more explicit guidance on how ERCs may be created and used. The following key provisions are found in Appendix S:

> *ERCs may be created through shutting down an existing emission unit or curtailing production or operating hours*[6] *if the emission reductions are surplus, permanent, quantifiable, and federally enforceable.*

Further clarification of the rules governing the creation, banking, and use of ERCs may be found in the U.S. EPA's Emissions Trading Policy Statement and the accompanying Technical Issues Document.[7] Emission reduction credits used as offsets must be "in the area of the proposed source …" such that there will be reasonable progress toward attainment of the applicable NAAQS. Emission reduction credits used as offsets must come from the same federal nonattainment area as the emission increase. Emission reduction credits from a different nonattainment area typically may be used if:[8]

1. The other area has an equal or higher (worse) nonattainment classification than the area in which the source is located, AND

[5] 40 CFR §51.165 (a)(9)(i)

[6] 40 CFR Part 51 Appendix S (IV)(C)

[7] 51 Federal Register 43812 (December 4, 1986)

[8] 40 CFR Part 51 Appendix S (IV)(D)

2. Emissions from such other area contribute to a violation of the NAAQS in the nonattainment area in which the source is located.

The intent of this policy is to reduce the emission inventory in the area with the worse air quality by moving emissions to an area that they are already traveling to anyway. Theoretically, there would be little adverse impact to either area.

The 1993 NOx Substitution Guidance Document (U.S. EPA 1993) states that SIPs may allow for NOx and VOC offset substitution if modeling shows that the NOx and VOC reductions achieved would produce an equivalent amount of ozone reduction in the nonattainment region of interest.

Beyond this, there is very little federal guidance regarding the creation and use of ERCs as NSR offsets, particularly in the areas on interpollutant and interdistrict trading. However, the Open Market Trading Rule (U.S. EPA 1995), which U.S. EPA issued in 1995, encouraged states to implement trading programs for discrete emission reductions (DERs) to facilitate compliance with emission standards.

> *In general, interpollutant trading rules should encourage excess VOC emission reductions in geographic locations where ozone is limited by available VOC or encourage excess NOx emission reductions in locations where ozone is limited by available NOx.*

And

> *States would be encouraged to assess their own unique situations and propose an Open Market Trading Rule that allowed NOx trades from outside the modeling domain at an appropriate discount or allowed VOC trades with adjacent nonattainment areas, after taking into account and justifying the distance and direction considerations.*

While this rule is not applicable to ERCs used as NSR offsets, the preamble does encourage environmentally beneficial interpollutant and interdistrict credit trading.

2.3 State Level (California) ERC Use Requirements

As mentioned above, each state is required to submit an SIP to the U.S. EPA indicating how each nonattainment area in the state will achieve attainment of the NAAQS by the required dates. The SIP is a compendium of district rules, state regulations, and federal requirements. In California, each air district works with the California Air Resources Board on their portion of the SIP. Because stationary sources are controlled by local air districts within California, the rules governing ERCs utilized as NSR offsets are district rules. This section describes the overarching state-level requirements.

The state-level rules governing offsets and ERCs are geared toward attainment of the more stringent State ambient air quality standards (SAAQS), not the federal ones. Health and Safety Code 40911 requires air districts classified as nonattainment for the state ambient standards for ozone, CO, SO_2, or NO_2 to submit a plan for attaining and maintaining the state standard. Because all districts currently attain the state standards for CO, SO_2, and NO_2, only ozone plans are currently required. Note that the State rule does not require a PM_{10} attainment plan.

The State plans required by Health and Safety (H&S) Code 40911 must include a stationary source control program designed to achieve "no net increases" in emissions of state nonattainment pollutants or their precursors. The nonattainment pollutants explicitly listed include: ozone, CO, SO_2, and NO_2. A plan to achieve no net increase in PM_{10} or $PM_{2.5}$ emissions is not explicitly required. These no-net-increase provisions are achieved by requiring offsets for new and modified sources, as indicated in Table 7. At the state level, the emissions thresholds for offset requirements depend on the attainment status. The state-level rules do not dictate offset ratios (district rules do). The attainment designations are defined in H&S 40921.5 and shown in Table 8. Note that the attainment designations for California Air Basins were provided in Table 5.

Table 7. State Requirements for District Offset Rules to Attain State Ambient Standards

State Attainment Designation*	Offset Requirements for New and Modified Sources	Health and Safety Code Citation
Moderate	Sources with the potential to emit 25 tpy or more of the nonattainment pollutant or its precursor(s) must offset the new emissions	H&S 40918
Serious	Sources with the potential to emit 15 tpy or more of the nonattainment pollutant or its precursor(s) must offset the new emissions	H&S 40919
Severe	Sources with the potential to emit 10 tpy or more of the nonattainment pollutant or its precursor(s) must offset the new emissions	H&S 40920
Extreme	All sources must offset emissions of the nonattainment pollutant or its precursor(s)	H&S 40920.5

* The attainment designation is made "without regard to the transport contribution" (H&S 40921)

Table 8. Definition of Attainment Designations for State Ambient Standards

Ozone	CO
0.09 < Moderate ≤ 0.12 ppm	9.0 < Moderate ≤ 12.7 ppm
0.12 < Serious ≤ 0.15 ppm	12.7 ppm < Serious
0.15 < Severe ≤ 0.20 ppm	n/a
0.20 ppm < Extreme	n/a

The Health and Safety code also contains provisions for interdistrict/interbasin ERC trades (H&S 40709.6). Emission increases may be offset with ERCs from another district if both sources are within the same air basin. Emission reduction credits from another air basin may be used if they meet two rules:

> Rule 1. ERCs are from an upwind district that has a worse nonattainment status than the downwind district, AND
>
> Rule 2. The downwind district is ***overwhelmingly*** impacted by emissions transported from the upwind district. This is consistent with the federal rule. However, a definition of "overwhelmingly" is not provided in this statute.

In 2001, the Third Triennial Assessment of Ozone Transport Impacts was published (ARB 2001) identifying transport couples[9] and assigning a classification of *overwhelming, significant,* or *inconsequential* to the impacts. Table 9 provides the classification of each transport couple from this report. Note that a given transport couple can have more than one classification since the impact could be overwhelming on one violation day and inconsequential on another. TIAX has not found any updates to the 2001 classification. It is not clear that the term "overwhelmingly" used in this assessment is linked to the term used in H&S 40709.6 and discussed in the previous paragraph.

In 2003, the California Air Resources Board (ARB) released a new regulation entitled "Ozone Transport Mitigation Regulations" (ARB 2001). The intent of this regulation was to address the impact of upstream districts on downstream districts' abilities to attain the state ozone standards. This regulation requires upwind areas to have NSR offset requirements that are equally as stringent as those for the downwind areas they are affecting. One of the results of this rule was to decrease the NSR threshold for offset requirements in San Francisco and five Sacramento area air districts from 15 tons/yr to 10 tons/yr (the threshold in the San Joaquin Valley).

[9] "Couples" are a pair of geographic areas: one considered upwind and one considered downwind.

Table 9. Classification of Ozone Transport Impacts (ARB 2001)

Transport Couple	Impact Characterization*
Broader Sacramento Area to Mountain Counties	O
Broader Sacramento Area to San Joaquin Valley	S, I
Broader Sacramento Area to San Francisco Bay Area	S, I
Broader Sacramento Area to Upper Sacramento Valley	O, S, I
California Coastal Waters to South Central Coast	S
Mexico to Salton Sea	O, S
Mexico to San Diego	O, S, I
San Francisco Bay Area to Broader Sacramento Area	O, S, I
San Francisco Bay Area to Mountain Counties	S
San Francisco Bay Area to North Central Coast	O, S
San Francisco Bay Area to North Coast	O
San Francisco Bay Area to San Joaquin Valley	O, S, I
San Francisco Bay Area to South Central Coast	S
San Joaquin Valley to Broader Sacramento Area	S, I
San Joaquin Valley to Great Basin Valleys	O
San Joaquin Valley to Mountain Counties	O
San Joaquin Valley to Mojave Desert	O
San Joaquin Valley to North Central Coast	S
San Joaquin Valley to South Central Coast	S, I
South Coast to Mojave Desert	O, S
South Coast to Salton Sea	O, S
South Coast to San Diego	O, S
South Coast to South Central Coast	S, I
South Central Coast to South Coast	S, I

*O = Overwhelming, S = Substantial, I = Inconsequential, due to several types of meteorology areas can have different impacts at different times of the year.

In addition to the offset provisions in the Health and Safety Code, ARB has issued guidance on interpollutant, interbasin, and short-term ERC trading in four additional documents: The ARB New Source Review Workshop Manual (ARB 1990), the Initial Statement of Reasons (ISOR) for the Credit Interchangeability Rule,[10] the Guidance for Power Plant Siting (ARB 1999), and Guidelines for the Generation and Use of Mobile Source Emission Reduction Credits (ARB 1996).

California Air Resources Board NSR Workshop Manual

---

[10] Title 17 California Code of Regulation, Sections 91500–91508, 1997.

The 1990 NSR Workshop Manual qualitatively discusses interbasin trades. Its overarching guidance is that emission increases must be offset and that the offsets should provide a net air quality benefit. It generally states that offsets should be located as close to the location of use as possible and that VOC emission reduction credits are acceptable if they are from the same area or from a nearby area contributing to an ozone nonattainment problem. By virtue of the discussion, though, it is clear that ARB has, in the past, supported interbasin ERC trading under defined circumstances.

Credit Interchangeability Rule

The 1997 Credit Interchangeability Rule allows ERCs to be used for compliance with district rules other than New Source Review. The rule states that precursors of nonattainment pollutants may be interchanged. However, since a ton of VOC is not necessarily equivalent to a ton of NOx in terms of ozone formation, these trades presumably must be evaluated carefully. A further complicating factor with NOx and VOC interpollutant trades is that both are precursors of fine particulate matter (PM_{10}). Therefore, if NOx and VOCs are interchanged, the impact on PM attainment needs to be evaluated as well.

Guidance for Power Plant Siting

The 1999 Guidance for Power Plant Siting discusses both interpollutant and interbasin trades. It states that interpollutant and interbasin trades should only be allowed after the new/modified source surrenders any ERCs it holds and it also demonstrates that additional creditable emission reductions are not available onsite or near the source. For interpollutant trades, VOC and NOx may be interchanged with a minimum ratio of 1.0 to 1 and specific to the air basin location. Moreover, the interpollutant trade may not prevent or interfere with the attainment of any ambient air quality standard (for example PM_{10}). For interbasin trades, the 1999 guidance document reiterates the H&S 40709.6 requirements that the upwind district have an overwhelming impact on the downwind district accepting the offsets. The guidance document also provides suggested offset ratios based on a survey of existing district distance offset ratios. ARB staff recommended that the minimum interbasin offset ratio be 2.0:1 for sources within 50 miles. When the distance between sources is greater than 50 miles, the ratio is to be increased by one for each additional 25 miles. However, the guidance document states that the staff’s ratios are not intended to prevent an applicant or a district from developing other interbasin offset ratios based on a detailed technical analysis.

Guidelines for the Generation and Use of Mobile Source Emission Reduction Credits (MSERCs)

The 1996 revised *Guidelines for Generation and Use of Mobile Source Emission Reduction Credits* (ARB 1996) was prepared by the Air Resources Board to assist individual air districts wishing to incorporate provisions for MSERCs in their NSR rules. In addition to the main criteria for creation of all ERCs (surplus, real/quantifiable, enforceable), the life of the MSERCs must be carefully considered and commensurate with the proposed use of the credit. The document suggests that MSERCs may be generated through: accelerated retirement of older vehicles, purchase of low and zero emission vehicles, vehicle retrofits, and vehicle replacements. These strategies are not meant to limit the types of projects utilized to generate MSERCs.

2.1 California Air District Requirements

In California, ARB has delegated permitting of stationary sources to the local air districts. Each air district has regulations for new source permitting. The following paragraphs summarize the offset rules for five main air districts in California: Bay Area (BAAQMD), Sacramento (SMAQMD), San Joaquin Valley (SJVAPCD), South Coast (SCAQMD), and San Diego (SDAPCD). In general the rules stipulate the "offset threshold" and the "offset ratio." The offset threshold establishes a source's emission rate, above which a new or modified source must comply with applicable offset rules. An offset ratio is the number of offsets required per unit (e.g., pounds per day or tons per year) of permitted emissions. For example, an offset ratio of 1.2:1 means that 1.2 tons per year of pollutant reductions are required for each ton per year of pollutant emitted. Keep in mind that State rules are silent on offset ratios, so offset ratios must be at least as stringent as the federal requirements.

The following sections describe the ERC requirements for the five largest air districts in California (BAAQMD, SMAQMD, SJVAPCD, SCAQMD, and SDAPCD). The ERC requirements are compared to federal and state requirements. Any provisions for interdistrict/interbasin, interpollutant and short-term trades are noted.

2.1.1 Bay Area Air Quality Management District

As shown in Figure 5, the Bay Area Air Quality Management District (BAAQMD) includes all of Napa, Marin, Contra Costa, Alameda, San Francisco, San Mateo, and Santa Clara counties, as well as the southern portion of Sonoma county and the southwestern portion of Solano county. The Bay Area Air Quality Management District is classified as moderate nonattainment for both the federal and state ozone standards. It is also classified as nonattainment for the State PM_{10} and $PM_{2.5}$ standards.

Figure 5. BAAQMD Jurisdiction

Source: California Air Resources Board.

Table 10 compares the offset thresholds and ratios specified in BAAQMD regulations to the state and federal requirements. For ozone precursors (NOx and VOC), BAAQMD requires a 1:1 ratio up to 35 tpy (federal threshold is 40 tpy) and then requires the federal 1.15:1 offset ratio. Even though PM_{10} offsets are not required by state or federal regulations, BAAQMD requires all PM_{10} projects emitting above the 1 tpy level to offset their emissions at a 1:1 ratio. In addition, SO_2 emissions are required to be offset; this is because SO_2 is a PM_{10} precursor.

Table 10. BAAQMD Offset Requirements

	Offset Requirements		
	Federal	State	BAAQMD
Offset Thresholds			
NOx (tpy)	40	10*	10
VOC (tpy)	40	10*	10
PM10 (tpy)	x	x	1
SO_2 (tpy)	x	x	1
Offset Ratios			
NOx	1.15:1	x	1.15:1 if > 35 tpy; 1:1 for 10-35
VOC	1.15:1	x	
PM10	x	x	1:1
SO_2	x	x	1:1

* Reduced from 25 tpy by ARB Ozone Transport Mitigation Rule

According to Regulation 2 Rule 2-2-302,[11] VOC offsets may be substituted for NOx offsets (but NOx offsets may not be substituted for VOC). Additionally, NOx and SO_2 offsets may be substituted for PM_{10} at the Air Pollution Control Officer's discretion. Regulation 2 Rule 2-2-607[12] states that mobile source emission reduction credits may be used as offsets. The District rules are silent on interbasin trading. Effectively, then, even with the state-level provisions that allow for interbasin trading, it may not be feasible to consummate such a trade without very detailed and direct agency input and support.

2.1.2 Sacramento Metropolitan Air Quality Management District

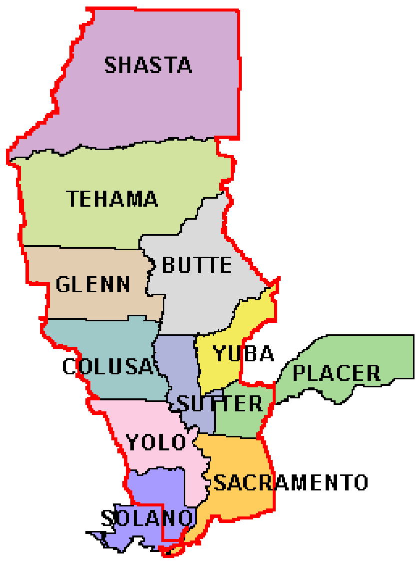
Figure 6 shows the Sacramento Valley Air Basin. The Sacramento federal ozone nonattainment area is a subset of this air basin. The federal nonattainment area includes all of Sacramento, Yolo and Butte Counties, and portions of Placer, Solano, Sutter, and Tehama Counties. The

[11] See http://www.baaqmd.gov/~/media/Files/Planning%20and%20Research/Rules%20and%20Regs/reg%2002/rg0202.ashx.

[12] See http://www.baaqmd.gov/~/media/Files/Planning%20and%20Research/Rules%20and%20Regs/reg%2002/rg0202.ashx.

Sacramento Metropolitan Air Quality Management District (SMAQMD) is comprised solely of Sacramento County. The neighboring air districts within the Sacramento federal nonattainment area have adopted rules that are generally consistent with the SMAQMD rules.

Figure 6. Sacramento Valley Air Basin



Source: California Air Resources Board

The Sacramento Metropolitan Air Quality Management District is a serious ozone nonattainment area for both the state and federal standards. In addition, it is classified as moderate nonattainment for the federal PM_{10} standard, nonattainment for the state PM_{10}, and nonattainment for federal and state $PM_{2.5}$ standards.

Table 11 provides the offset threshold and ratio requirements for SMAQMD. The District is unique in that rather than maintaining the offset currency in tons per year or pounds per day, it is in pounds per quarter. As can be seen, the offset thresholds for NOx and VOC are consistent with State requirements, but more stringent than federal requirements. The PM_{10} threshold is consistent with federal requirements (the state does not require PM_{10} offsets, even in areas that do not attain the State PM_{10} ambient standard). Sulfur dioxide offsets are required by the district to reduce PM_{10} emissions.

Table 11. SMAQMD Offset Requirements

	Offset Requirements		
	Federal	State	SMAQMD
Offset Thresholds			
NOx (tpy)	25	10*	5,000 lb/qtr (~ 10 tpy)
VOC (tpy)	25	10*	5,000 lb/qtr (~ 10 tpy)
PM10 (tpy)	15	x	7,500 lb/qtr (~15 tpy)
SO_2 (tpy)	x	x	13,650 lb/qtr (~27.3 tpy)
Offset Ratios			
NOx	1.2:1	x	1.3:1 if < 15 miles, otherwise 1.5:1
VOC	1.2:1	x	
PM10	1:1	x	1:1 if < 15 miles otherwise 1.5:1
SO_2	x	x	

* Reduced from 15 tpy by ARB Ozone Transport Mitigation Rule

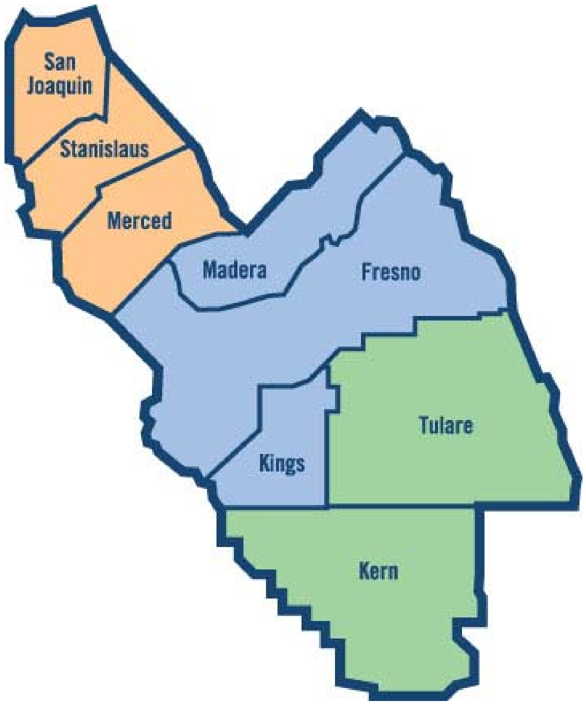
The offset ratios for ozone precursors (VOC and NOx) are more stringent than the federal requirements and are dependent on location. Offsets may come from other districts, but NOx and VOC emission reduction credits must come from the federal nonattainment area (see above, which consists of seven counties, and is a subset of the Sacramento Air Basin).

In the SMAQMD Rule 214 of their Rules and Regulations, Standard 304 states that interpollutant trading is discouraged, but may be allowed on a case-by-case basis if ambient modeling shows that it provides an air quality benefit (SCAQMD 2010). Rule 206, Mobile and Transportation Source Emission Reduction Credits, allows mobile source emission reduction credits to be used by stationary sources, but does not mention other short-term credit mechanisms.

2.1.3 San Joaquin Valley Air Pollution Control District

The San Joaquin Valley Air Pollution Control District (SJVAPCD), located in California's central valley is one of the state's largest air districts (geographically speaking). It consists of seven counties plus the valley portion of Kern County as shown in Figure 7. The San Joaquin Valley Air Pollution Control District is classified as serious nonattainment for both federal and state ozone and $PM_{2.5}$ standards. It is also classified as nonattainment for the State PM_{10} standard.

Figure 7. SJVAPCD Jurisdiction, Color-Coded by North, Central, and Southern Portions of the Valley



Source: San Joaquin Valley APCD

Table 12 provides a summary of the SJVAPCD offset thresholds and ratios. The thresholds for ozone precursors are more stringent than the state and federal thresholds. The PM_{10} threshold is just under the federal threshold; recall that the state does not require PM_{10} offsets. Offsets are required by the District for SO_2 emissions as a precursor to fine particulate. Table 12 also indicates that the offset ratios scale with distance from the source. If the offsets come from the source, the ratio is 1.0:1. If the source of the offsets is on-site, the ratio is 1:1; within 15 miles, the ratio is 1.3:1. If the source is greater than 15 miles away, the ratio is 1.5:1.

One interesting feature of the SJVAPCD New Source Review rules (Rule 2201) is that before an ERC can be banked, a 10 percent Air Quality Improvement Deduction is assessed. Additionally, stationary agricultural sources are exempted from offset requirements per California H&S 42301.18.

Table 12. SJVAPCD Offset Requirements

<table>
<tr><th rowspan="2"></th><th colspan="3">Offset Requirements</th></tr>
<tr><th>Federal</th><th>State</th><th>SJVAPCD</th></tr>
<tr><td>Offset Thresholds</td><td></td><td></td><td></td></tr>
<tr><td>NOx (tpy)</td><td>25</td><td>15</td><td>10</td></tr>
<tr><td>VOC (tpy)</td><td>25</td><td>15</td><td>10</td></tr>
<tr><td>PM10 (tpy)</td><td>15</td><td>x</td><td>14.6</td></tr>
<tr><td>SO_2 (tpy)</td><td>x</td><td>x</td><td>27.4</td></tr>
<tr><td>Offset Ratios</td><td></td><td></td><td></td></tr>
<tr><td>NOx</td><td>1.2:1</td><td>x</td><td rowspan="4">1:1 on-site;
1.3:1 ≤ 15 mi;
1.5:1 > 15 mi</td></tr>
<tr><td>VOC</td><td>1.2:1</td><td>x</td></tr>
<tr><td>PM10</td><td>1:1</td><td>x</td></tr>
<tr><td>SO_2</td><td>x</td><td>x</td></tr>
</table>

On interbasin trades, SJVAPCD Rule 2201, **New and Modified Stationary Source Review Rule,** states that offsets may come from another air district but only if the source of the ERCs is within 50 miles of the proposed user of the ERCs and subject to state interbasin trading limitations. Interpollutant trading is allowed on a case-by-case basis if the applicant demonstrates that the emission increase will not cause or contribute to a violation of an ambient air quality standard. Further, the Air Pollution Control Officer shall impose offset ratios equal to or greater than the requirements of Rule 2201. Interpollutant trades that can be considered are:

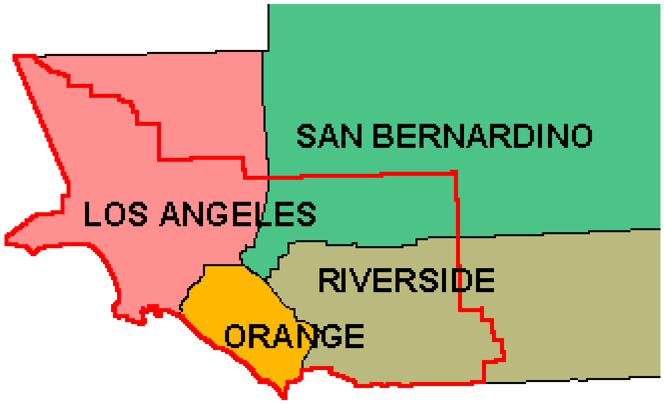
- NOx, VOC, and SO_2 may be substituted for PM_{10} (but not the converse)
- NOx may be substituted for VOC
- VOC may be substituted for NOx

Rule 2201 does not have provisions for the use/creation of short-term ERCs.

2.1.4 South Coast Air Quality Management District

Figure 8 shows the South Coast Air Quality Management District (SCAMQD) jurisdiction. It consists of all of Orange County and the western portions of Los Angeles, San Bernardino, and Riverside counties. The District is classified as severe nonattainment for the federal and state ozone standards. It is also classified as serious nonattainment for the federal PM_{10} standard. It is nonattainment for the state PM_{10} standard and both the state and federal $PM_{2.5}$ standards.

Figure 8. South Coast Air Quality Management District Jurisdiction



Source: California Air Resources Board

Table 13 summarizes the offset thresholds and ratios. SCAQMD Rule 1303 requires offsets for any increase of a nonattainment contaminant or its precursor, though this is modified by Rule 1304(d), which provides for a 4 tons/yr offset exemption for VOCs, NOx, Sox, and PM_{10}, and 29 tons/yr for CO. This threshold is lower than the state and federal requirements. However, the offset ratios for NOx and VOC are not as stringent as the federal requirement.[13]

Table 13. SCAQMD Offset Requirements

	Offset Requirements		
	Federal	State	SCAQMD
Offset Thresholds			
CO (tpy)	x	x	29
NOx (tpy)	25	10	4
VOC (tpy)	25	10	4
PM10 (tpy)	15	x	4
SO_2 (tpy)	x	x	4
Offset Ratios			
NOx	1.3:1	x	1.2:1
VOC	1.3:1	x	1.2:1
PM10	1:01	x	1.2:1
SO_2	x	x	1.2:1

Interbasin trades are allowed but (1) they must originate in an upwind district with worse attainment status, and (2) the downwind district must be "overwhelmingly" affected by the upwind district (the same as state requirement).

[13] The offset ratio in this case is allowed to be lower because, overall, the NSR rule has been deemed by the U.S. EPA to be as stringent as the federal requirements.

According to SCAQMD Rule 1309, interpollutant trades are allowed on a case-by-case basis if the applicant can show that they will not cause or contribute to violation of an ambient air quality standard. The rule explicitly states that all interpollutant trades are subject to U.S. EPA review and approval. The following interpollutant trades may be considered:

- NOx, VOC, SO_2 may be substituted for PM_{10} (but not the converse)
- NOx may be substituted for VOC
- VOC may be substituted for NOx

The SCAQMD rules also provide for short-term credits (STCs). These credits can be derived from area source reductions as well as reductions from mobile sources. Traditional ERCs are permanent, whereas STCs are issued and reviewed on a yearly basis, and the applicant must provide a minimum of five consecutive years of STCs. The ERC offset ratios described above are applicable to STCs.

The SCAQMD is unique in that it has maintained an internal bank of ERCs and during the energy crisis (~2000), it set up a Priority Reserve to ensure that new electricity generating capacity would have sufficient ERCs to begin construction. In 2007, SCAQMD was sued by the National Resources Defense Council (NRDC) and other environmental groups concerning the priority reserve and how AQMD accounts for the quantity of emissions reductions available to fund the Priority Reserve per Rule 1309.1 and offset exemptions per Rule 1304d.

Recall that under the federal and state Clean Air Acts, SCAQMD is the permitting authority for stationary emission sources within its jurisdiction. It can only issue permits for new sources if the emissions increases are offset with emission reductions from other sources (ERCs). The SCAQMD generated the emissions reductions it needed to fund the Priority Reserve and the offset exemption by tracking source shutdowns and other methods to reduce emissions and keeping those offsets for itself to fund the priority reserve and offset exemption. The emission reductions were kept in what is referred to as SCAQMD's *internal bank.* Previously, if a new source's emissions were below 4 tons per year, the SCAQMD provided the needed offsets in the form of an exemption from the offset requirement (mentioned above, Rule 1309.4).

The NRDC suit challenged SCAQMD's tracking methodology and accuracy of accounting under SCAQMD Rule 1315 and certain amendments to Rule 1309.1, along with aspects of the overall rule adoption under CEQA. The court ordered that SCAQMD was prohibited from taking any actions to implement Rule 1315 or the amendments to Rule 1309.1 until it has prepared a new environmental assessment under the California Environmental Quality Act (CEQA).

Therefore, the only new permits that SCAQMD issued as of the end of 2009 are permits for new sources under 0.5 lbs/day of emissions or, if greater than 0.5 lbs/day emissions, where the new source could provide an adequate quantity of third party or external offsets to offset the new source emissions.

2.1.5 San Diego Air Pollution Control District

The San Diego Air Pollution Control District (SDAPCD) is located in the southern portion of the state and consists entirely of the County of San Diego. It is designated as serious nonattainment for the federal 8-hr ozone standard; however, it is designated as moderate nonattainment for the California 8-hr ozone standard. Additionally, SDAPCD is nonattainment for the state PM_{10} and $PM_{2.5}$ standards.

Table 14 summarizes the offset thresholds and ratios. As can be seen, the NOx and VOC thresholds are consistent with the federal requirement, but higher than the state thresholds. The offset ratios are consistent with federal requirements.

Table 14. San Diego APCD Thresholds and Offset Requirements

	Offset Requirements		
	Federal	State	SDAPCD
Offset Thresholds			
NOx (tpy)	25	15	25/50*
VOC (tpy)	25	15	25/50*
PM10 (tpy)	x	x	x
SO_2 (tpy)	x	x	x
Offset Ratios			
NOx	1.2:1	x	1.2:1
VOC	1.2:1	x	1.2:1
PM10	x	x	x
SO_2	x	x	x

* 25 tpy for a modification at an existing source, 50 tpy for a new source

According to SDAPCD Rule 20.1, all ERCs used as offsets must come from San Diego County. Interbasin trading is not allowed. Interpollutant trading is allowed:

- NOx ERCs may be substituted for VOC emission increases on a 1:1 basis.
- VOC ERCs may be substituted for NOx emission increases on a 2:1 basis.

The SDAPCD also allows the banking of limited ERCs. These result from the early implementation of a control measure from a SIP or Regional Air Quality Strategy (RAQS). Essentially, these are short-term ERCs that expire on the date that the measure is actually required to take place. For example, if a control is required to be installed by December 31, 2010, but the company installs the control December 31, 2009, the company has short-term credits that expire on December 31, 2010. There is an additional provision for what is termed “limited duration” ERCs, which operate similarly, however, they expire at a day set forth by the emitter (and approved by the District).

Finally, SDAPCD Rule 27 allows for the creation and use of MSERCs. These credits may be created through early retirement of mobile sources, replacement of urban buses with lower emission buses, emission retrofits, and other actions.

2.2 Discussion

The federal, state and district level rules for five of the largest air districts in California were reviewed to better understand interpollutant, interbasin, and short-term credit trading restrictions. That review found that interpollutant trading is difficult in districts where there are no pre-defined trading ratios. In these districts, the burden is on the applicant to prove that the trade is beneficial to air quality. Three of the five districts require the applicant to provide ambient modeling analyses to prove that any proposed interpollutant trade will not cause or contribute to a violation of any air quality standard. In other areas, such as SDAPCD, the offset ratios are predefined based on modeling performed by the district at some point in time that may not be representative of current local ozone formation conditions. The SDAPCD modeling indicates that NOx creates more ozone formation than VOC, and therefore their offset ratios reflect this.

Interbasin trading rules only allow trades from more populated areas to more remote areas (emissions removed from populated areas, new sources added in remote areas). Because emission sources are generally located in the more populated areas, the most likely interbasin trades are essentially prohibited. Finally, existing short-term ERC trading consists entirely of limited lifetime ERCs denominated on an annual basis.

It may be beneficial from both market and air quality perspectives if periodic ambient modeling was performed for the main air districts failing to attain ambient standards. Based on the modeling, specific guidance could be developed on (1) whether interbasin and interpollutant trades are beneficial, (2) which specific trades should not be allowed, and (3) defining the appropriate offset ratios. If the analysis resulted in easy access to interpollutant and interbasin ERC trading, it is likely that ERC supplies, and therefore prices, would improve.

Table 15 summarizes the interpollutant trading provisions from the five air districts considered.

Table 15. Summary of Interpollutant Trading Provisions for the Air Districts Considered

Air District	Ambient Modeling Required?	NOx ERC Substituted for VOC Emission Increase?	VOC ERC Substituted for NOx Emission Increase?
Bay Area AQMD	No	No	Yes, 1.0:1 ratio
Sacramento Metropolitan AQMD	Yes	Discouraged	Discouraged
San Joaquin Valley APCD	Yes	Yes, ratio based on modeling results	Yes, ratio based on modeling results
South Coast AQMD	Yes	Yes, ratio based on	Yes, ratio based on

Air District	Ambient Modeling Required?	NOx ERC Substituted for VOC Emission Increase?	VOC ERC Substituted for NOx Emission Increase?
		modeling results	modeling results
San Diego APCD	No	Yes, 1.0:1 ratio	Yes, 2.0:1 ratio

Clearly, a significant burden is placed on project developers in the three districts requiring ambient modeling. This burden deters interpollutant trading. In different districts, the various interpollutant ratios or prohibition of interpollutant trades may be predicated on indications that VOC emissions in some areas have a greater or lesser impact on ozone formation. On the other hand, these ratios and prohibitions may be predicated on past decisions that may no longer be applicable. From an ERC market perspective, it would likely be beneficial if a State agency could periodically perform modeling for each air district and provide technically sound guidelines on interpollutant trades (including ratios) that reflect the relative merits of reducing NOx or VOC in a given geographic region. Theoretically, explicit rules based on science would enhance ERC markets.

Table 16 summarizes the allowable interbasin trading for ozone precursors based on ARB's impact findings shown previously in Table 9 (only "overwhelming" impacts are shown). In general, the only allowable trades are from populous areas to more remote locations. The only exception would be trades from the South Coast Air Basin to San Diego. Currently, San Diego regulations prohibit interbasin trades. Because new electricity generation capacity will mainly be needed in the more populated areas of the state and along transmission lines, the existing state and federal ERC rules are a hindrance for power plant developers.

Table 16. Allowable Interbasin Trading for Ozone Precursor ERCs

Upwind Location	Overwhelmingly Impacted Downwind Location	Upwind Attainment Status Worse than Downwind?	Interbasin Trade Allowed?
Sacramento Area	Mountain Counties	Yes	From Sacramento to Mountain Counties
San Francisco Bay Area	Sacramento	No	No
San Francisco Bay Area	North Central Coast	No	No
San Francisco Bay Area	North Coast	No	No
San Francisco Bay Area	San Joaquin Valley	No	No
San Joaquin Valley	Great Basin (east of SJV)	Yes	From SJV to Great Basin
San Joaquin Valley	Mountain Counties	Yes	From SJV to Mountain Counties
San Joaquin Valley	Mojave	Yes	From SJV to Mojave
South Coast	Mojave	Yes	From South Coast to Mojave

Upwind Location	Overwhelmingly Impacted Downwind Location	Upwind Attainment Status Worse than Downwind?	Interbasin Trade Allowed?
South Coast	Salton Sea (East of San Diego)	Yes	From South Coast to Salton Sea
South Coast	San Diego	Yes	From South Coast to San Diego

If a proposed project is to be sited in a location where credits are needed, the project must be in a nonattainment area, and therefore by definition in an area where the district is under pressure to reduce emissions, not add them. For this fact alone, permitting authorities have no incentive to allow an applicant to bring an ERC from an upstream location into their district. Allowing ERCs to enter the district is at odds with its mission to reduce its inventory. Therefore, there is very little incentive for a district to allow interbasin trades in its rules.

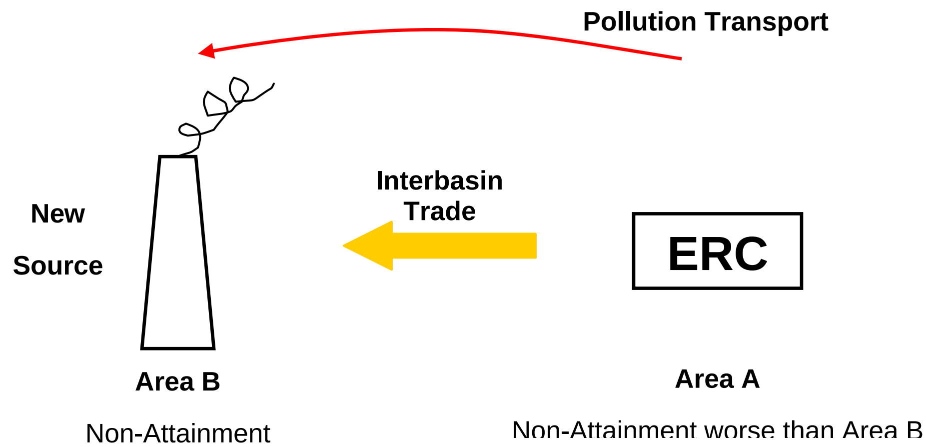
However, it may be that there are circumstances in which interbasin trading beyond what is allowed in the federal/state provisions is environmentally beneficial for the region (e.g., SF Bay Area – Central Valley). Currently, the air district geographic boundary definitions prevent these types of trades from happening. By modeling ozone formation and upwind/downwind impacts to determine whether state and federal restrictions are warranted from an environmental perspective, it would provide information on which trades could be benign.

2.3 Summary

2.3.1 Interbasin Trading Provisions

The federal, state, and local provisions for more flexible ERC trading were also reviewed. In summary, the state requirements for interbasin trading are essentially equivalent to the federal guidance. In general (and shown in Figure 9, a new source located in Area B may utilize ERCs created in Area A if Area A has worse air quality than Area B AND Area A emissions adversely impact Area B's air quality. The intent of this policy is to reduce the emission inventory in the area with the worse air quality by moving emissions to an area that the emissions are already traveling to anyway. Theoretically, there would be little adverse impact to either area. Figure 9 illustrates an allowable interbasin trade.

Figure 9. Illustration of an Allowable Interbasin Trade



Interbasin trades require a determination that Area A affects the attainment status of Area B. The state requires that the emissions transported from Area A *overwhelmingly* impact Area B. The term *overwhelming* is not quantitatively defined, but rather depends on the assessment of the California Air Resources Board and districts to determine whether "the contribution level of transported air pollutants is overwhelming, significant, inconsequential, or some combination thereof."[14] The most recent ARB analysis of transport was performed in 2001, and only ozone (NOx and VOC emissions) was considered. Table 17 illustrates the allowable trades based on current attainment status and the 2001 ozone transport couples. As can be seen, for the major air districts, only one trade is clearly allowable—South Coast AQMD to San Diego APCD.

Table 17. Logic for Allowable Interbasin Trades

ERC Trade Area A → Area B		Area A Attainment Status Worse Than Area B?	Area A Emissions Overwhelmingly Impact Area B's Attainment?	Interbasin Trade Allowable?
Area A	Area B			
SF Bay Area	Sacramento Metro	No	Yes	No
SF Bay Area	San Joaquin Valley	No	Yes	No
Sacramento Metro	SF Bay Area	Yes	No	No
Sacramento Metro	San Joaquin Valley	No (same)	No	No
San Joaquin Valley	SF Bay Area	Yes	No	No
San Joaquin Valley	Sacramento Metro	No (same)	No	No
South Coast	San Diego	Yes	Yes	Yes
San Diego	South Coast	No	No	No

[14] California Health and Safety Code Section 26, § 39610. Identification of transported pollutant section b).

2.6.2. Interpollutant Trading Provisions

While there is very little federal guidance on interpollutant trading, the state allows precursors of nonattainment pollutants to be interchanged (ARB 1997). However, since a ton of VOC is not necessarily equivalent to a ton of NOx in terms of ozone formation, interpollutant trades must be evaluated carefully in each air district. Moreover, NOx and VOC are precursors of PM, so interpollutant trading of VOC and NOx must consider the impact on PM attainment as well.

Finally, rules governing short-term credits were evaluated. In 1997, ARB provided guidance to the local air districts regarding incorporation of MSERCs into their rules. To date, only SCAQMD has MSERC rules. All of the air districts reviewed except for San Joaquin Valley have provisions in their rules for creation and use of MSERCs. In the SCAQMD, qualified MSERCS obtained from activities such as scrapping or retrofitting in-use vehicles can be traded or sold on the open market and used to offset emissions from stationary sources, RECLAIM (the power plant credit trading program), or employee commute programs that reduce overall miles driven and the mobile source pollution. Aside from MSERCs, there are no provisions at the federal, state, or local level for short-term trades.

2.6.3. Conclusions

After review of federal, state, and local ERC use rules and policy, this study found the following:

- State and district rules act to reduce the supply of ERCs faster than the federal requirements
    - The state has set much lower applicability thresholds than the federal requirement for NOx and VOC. The federal applicability thresholds for NOx and VOC are potential emissions of 40 tons/yr. The state applicability thresholds for NOx and VOC are 10 tons/yr, requiring many more new stationary sources to obtain and surrender ERCs than the federal requirement.
    - Many local air districts have set lower applicability thresholds than the state requirements, and one has even required offsets for an attainment pollutant.[15]
    - Three of the five local air districts reviewed have higher offset ratios than the federal requirement.
    - Some districts have allowed ERCs to be surrendered in lieu of complying with emission limits.
- Periodic air quality modeling of ozone formation would help to provide a consistent scientific basis for interpollutant and interbasin ERC trading rules.
    - In general, interpollutant trading is onerous in the districts where explicit trading ratios are not stipulated. It would be helpful if air quality modeling was

[15] BAAQMD requires PM_{10} offsets even though it attains the PM_{10} ambient standard.

performed for each district on a periodic basis to provide appropriate explicit interpollutant trading ratios based on consistent science.

  - Interbasin trading is generally allowed from populous areas to adjacent more remote areas. Because new electricity generation capacity will mainly be needed in the more populated areas of the state and along transmission lines, the existing state and federal ERC rules will discourage interbasin trading. Furthermore, air districts have no incentive to allow interbasin trading even if these trades are shown to be beneficial for the region as a whole. It would be helpful if regional modeling could periodically be performed (this could be in conjunction with the interpollutant modeling discussed above) to determine whether interbasin trades are environmentally beneficial and if so at what ratios. The most recent analysis by the state on interbasin ozone impacts was performed in 2001.

- Short-term ERC trading is allowed in most of the districts, but these are all denominated in tons/year over a limited lifetime (rather than in perpetuity, as typical ERCs). Building power plants takes significant investment of capital; limited lifetime ERCs are much less attractive to developers than traditional perpetual ERCs. Short-term ERCs that would be attractive to power plant developers would be ERCs that allow operation during peak summer hours only, in perpetuity. For example, a new peaking power plant would like a perpetual ERC to emit on summer afternoons from 12 noon to 6 p.m. These ERCs would be created if another stationary source were willing (for a price) to curtail operation perpetually from 12 noon to 6 p.m. on summer afternoons. It would appear that this type of ERC transaction could be accommodated by districts without additional modeling. However, finding existing stationary sources willing to take such a permit limit to create these ERCs would be difficult.

CHAPTER 3: Air Quality Modeling

This chapter discusses air quality modeling of trading scenarios. In this task, the Community Multiscale Air Quality Model (CMAQ) was applied to simulate air quality in Central California. The database collected during the summer 2000 Central California Ozone Study (CCOS) is used to prepare model inputs and to evaluate meteorological simulations and chemical outputs. The model has stable performance for the entire modeling period and is able to reproduce reasonably the ozone and its precursor species concentrations observed in the San Joaquin Valley. For this task, several possible inter-basin trading scenarios were analyzed to determine their potential to affect ozone concentrations in Northern California. This task was designed to support two objectives: the first of which is discussed in this report, and the second of which is addressed in a separate LBNL report entitled, *A Seasonal Perspective on Regional Air Quality in Central California* (Harley et al. 2006.) Additional information on the more general aspects of the model development, including quality assurance procedures, and sensitivity analysis may also be found in the LBNL report.

The two objectives that this task was designed to support are:

- to determine whether existing rule limitations may possibly exclude beneficial or environmentally benign trades, and if so, which trades these may be; and
- to gain insight into the capabilities of today's modeling and methodologies and provide recommendations on what modifications would be needed for a full-scale analysis that is accurate and flexible enough for use in a regulatory platform.

By design, the scoping analysis was limited and was used only to explore various trade options. The study had several limitations: (1) only ozone precursors, not PM, were investigated, (2) the region was limited to Northern and Central California, and (3) the modeling year was limited to the year 2000. If this scoping study and credit trading project indicate there may be potential for expansion of the allowable trades while maintaining air quality, these and other items are recommended below to be included in future analyses. A complete list of these recommendations can be found in the Recommendations section.

3.1 Methodology

3.1.1 Ozone Effects of Pending Power Plants

The first step in the analysis was to quantify the number of ERCs needed by electric generating units to obtain a construction permit from the local air district. Two different types of electricity generating power plants were considered: a combined-cycle natural-gas-fired combustion turbine (CCCT) and a simple-cycle natural-gas-fired combustion turbine (SCCT). It was assumed that the CCCT would be base loaded (operate at high capacity factor) while the SCCT would be operated as a peaking unit (only on hot summer afternoons). Table 18 provides the estimated emission factors and hourly emission rates from these units assuming they have installed the lowest achievable emission rate (LAER) emission control equipment.[16]

Table 18. Hypothetical Electric Generating Units Modeled

	Capacity MW	Emission Rates			Emissions, lb/hr		
		NOx, ppm 15% O_2	VOC, ppm 15% O_2	PM_{10} lb/MMBtu	NOx	VOC	PM_{10}
Base Loaded Combined-Cycle Turbine	500	2	1.4	0.0075	38	7	28
Peaking Simple-Cycle Turbine	150	3.5	2	0.0075	24	4	10

In the scoping simulations, first, the impact of both base load and peaker power plants on the ozone concentration in Central California were compared, and second, the effects of additional base loaded power plants were analyzed at different locations on downwind regions.

The emissions associated with each type of power plant are multiplied by 10 as the input to the model, in order to discern a reasonable ozone signal. The additional emissions and the base case anthropogenic sources are given in Appendix A for different source categories, days of week, and subregions. The inputs are defined as:

- **"Peaker Case":** Addition of emissions from 10 typical peaker plants (145 MW total), emitting a total of 0.7 tons/day of NOx and 0.1 tons/day of VOCs, operating from 12:00 p.m. to 6:00 p.m.
- **"Base Loaded Case":** Addition of emissions from 10 typical base loaded combined-cycle plants (500 MW total), emitting a total of 4.4 tons/day of NOx and 0.8 tons/day of VOCs, operating continuously over a 24-hour period.

The results of the comparison of the two plant types indicated that the impacts from the peaker plants, running from 12:00 p.m. to 6:00 p.m. are much less significant than the base loaded plants, due to less NO_x and VOC emissions and shorter operation times. Peaker power plants have very localized effects: ozone changes are most frequently less than 1 ppb in the domain, except at the source location during the operation hours.

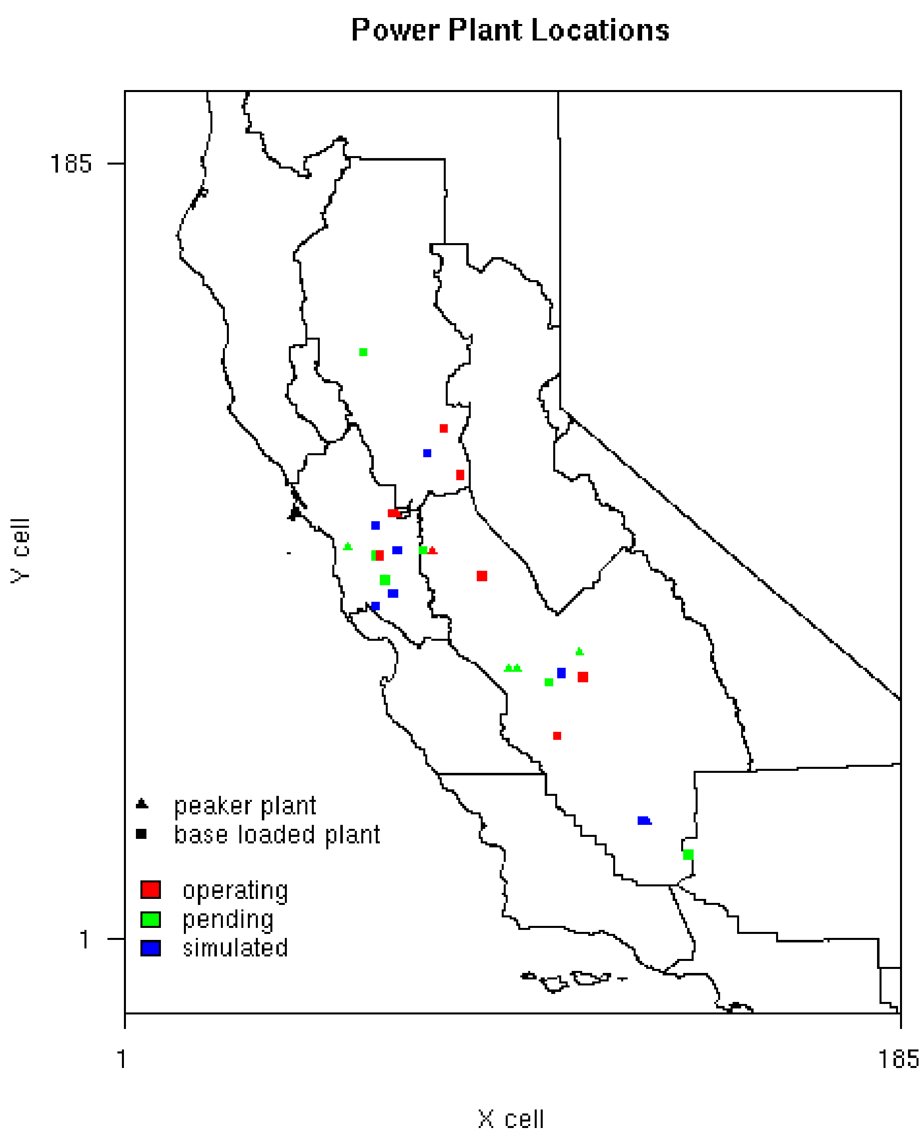
As a result of these simulations, subsequent efforts focused only on the base loaded power plant emissions and evaluated the effects of different source locations: in the San Francisco Air Basin,

[16] This equipment is low-NOx burners with selective catalytic reduction for NOx control and an oxidation catalyst for VOC control.

Sacramento Valley, and San Joaquin Valley (Fresno County and Kern County). Additionally, only NOx emissions were considered in this study because the VOC emissions associated with these power plants are so small that no discernable ozone signal is associated with them.

Next, it was determined where new electricity generating capacity was needed. To evaluate the effects of possible trading scenarios, first, the status of current and proposed or pending power plant facilities were obtained, along with their descriptions and their location. The exact latitudes and longitudes of the locations were found through a web search and were converted to our gridded domain coordinates (Figure A-1, Appendix A). Figure 10 shows the simulated power plant locations.

Figure 10. Locations and Types of Current Operating and Pending Power Plants, Along with Simulated Ones (as of December 2010)



Next, the ozone effects of potential emissions from the pending power plants were modeled based on simulation results at local time 3:00 p.m., when (in general) the ozone peak usually occurs, and when the added power plant emissions usually result in an ozone increase in the downwind areas. To discern a noticeable perturbation in the modeling, each scenario is modeled using the addition of 10 average-sized base or peaker loaded plants at the location to be modeled. Then, if the result is discernable (> 1 ppb absolute value change in maximum ozone increase at 3:00 p.m.), the result is scaled back to the original size of the power plant to be modeled (Appendix A, Table A-1). If the result of the modeled 10x plant is less than 1ppb, then the value is said to be zero, since it is below the model's detection limit.

As an example, the plant at Panoche Energy Center is equivalent in size to 2.7 average peaker plants. The modeled change in ozone due to 10 peakers nearby was calculated. If the predicted value of the impacts from the calculated value of 10 peakers is 3 ppb, the actual impact of the Panoche Energy Center would be calculated by multiplying 3 by (2.7/10) to obtain 0.8 ppb, which would be seen in the potential impact column. In this case the resulting concentrations less than 1 ppb are still considered significant because the predicted value before scaling is greater than 1 ppb.

Simulated ozone concentration maps and an ozone sensitivity map (shown in Appendix A, Figures A-1, A-2) are used to estimate ozone changes resulting from emission changes (perturbations) at the locations where emissions are perturbed, (i.e., close to the actual power plant sites). The sensitivity map provides the first-order semi-normalized ozone sensitivity coefficient with respect to NO_x emissions:

$$S_i^{(1)} = P_i \frac{\partial C}{\partial p_i} = \frac{\partial C}{\partial \varepsilon_i}$$

where, P_i is a base case input parameter (NO_x emissions in this case), whose perturbation p_i is considered in a relative sense by defining a scaling variable ε_i, with its nominal value being 1; $\boldsymbol{C}$ is the ozone concentration. The sensitivity coefficient has concentration units. $S_i^{(1)} = \alpha$ ppb implies that a 10 percent change in the parameter (NO_x emissions) would cause ($\alpha \times 10\%$) ppb change in the ozone concentration when all other variables are held constant.

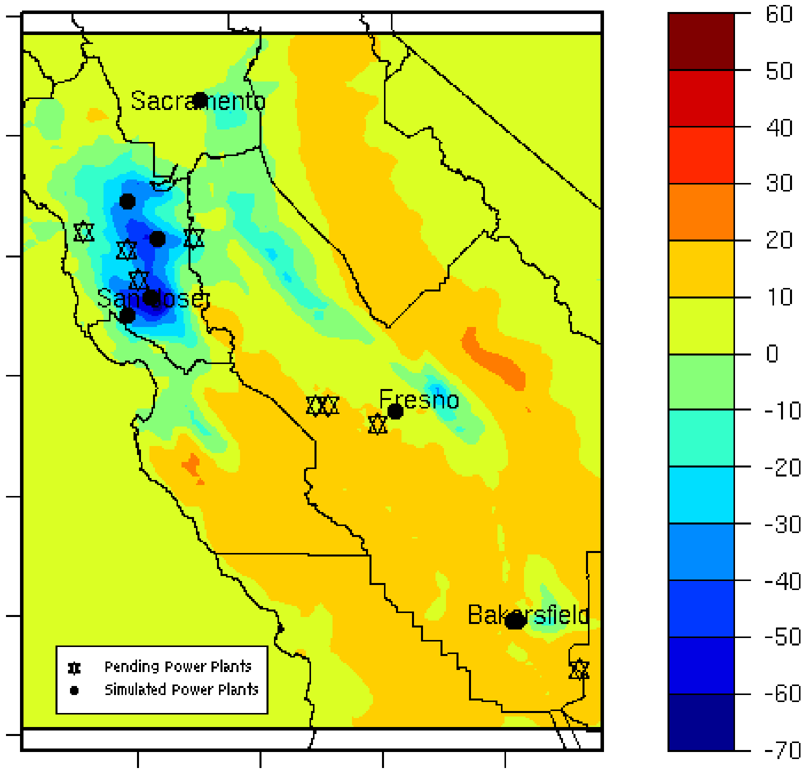
The air quality modeling results depend to a large degree on the local ozone formation characteristics. Some areas in California (especially in the Bay Area) are "VOC limited," and some are also NOx-disbenefit too. In these regions, decreases in local NOx emissions are counterproductive—they cause an increase in ozone formation. Decreases in VOC emissions, however, do result in decreases in ozone. Therefore, in NOx disbenefit areas, ozone attainment strategies generally focus on VOC reduction (not NOx increases).

A negative sensitivity indicates that the local ozone chemistry is in a *NO_x disbenefit* regime, that is, removing NO_x emissions will increase ozone, while adding NO_x emissions will decrease ozone. A positive sensitivity indicates a *NO_x benefit* regime, that is, removing NO_x emissions will reduce ozone and adding NO_x emissions will increase ozone.

Power plants contribute more NOx emissions than VOC emissions to an area, so theoretically, in NOx disbenefit regions, the addition of a power plant would reduce ozone formation. Conversely, trading NOx emission reduction credits out of a NOx disbenefit area would increase ozone formation in that area. Figure 11 is a map of the ozone sensitivity in the modeling domain to changes in NOx emissions due to installation of new power plants. Approximately 5 tons per day (tpd) of NOx emissions were added to the current inventory at the points labeled "Simulated Power Plants." The figure shows the change in ozone levels (ppb) when these emissions are added. Most of the areas are NOx limited and show an increase in ozone due to the added NOx emissions. The order of increase is typically around 10 ppb.

However, in NOx disbenefit region, the added NOx causes is a reduction of up to 70 ppb. This effect is typically immediately downwind of the power plant, in the Bay Area and east of Sacramento, Fresno, and Bakersfield. This figure is meant to illustrate the NOx disbenefit effect and is not an example of a realistic scenario.

Figure 11. Illustration of Change in Ozone with Increases in New Power Plant NOx Emissions (ppb)



Finally, the locations where perturbations occurred and the pending power plant locations were plotted onto the sensitivity map (Appendix A, Figure A-2). A comparison was made to see if the findings from the handful of simulated power plants modeled in this study (denoted by dots in Figure 11) will have similar impacts as the many pending power plants across the region (denoted by XX in the figure). These locations of the simulated and pending power plants in the Bay Area are both located in a NO_x disbenefit area (NOx disbenefit regions are colored blue in the figure). The simulated locations in Fresno and Kern counties in the SJV are located in areas with small ozone sensitivity (0~10 ppb) to NOx emissions (colored light yellow), while the pending power plants in these counties are located in areas that are more sensitive (10–20 ppb) to NOx emissions. Therefore, the ozone increases that would be caused by pending power plants in the SJV may be greater than our simulated estimates, since their locations are in a more sensitive NOx regime. Similarly, the pending power plant in the Sacramento valley is located in a rural area, while the simulations were conducted for a location in the Sacramento metropolitan area; hence, ozone increases are expected to be greater for the pending power plant in the Sacramento Valley.

3.1.2 Assessment of Trading Scenarios

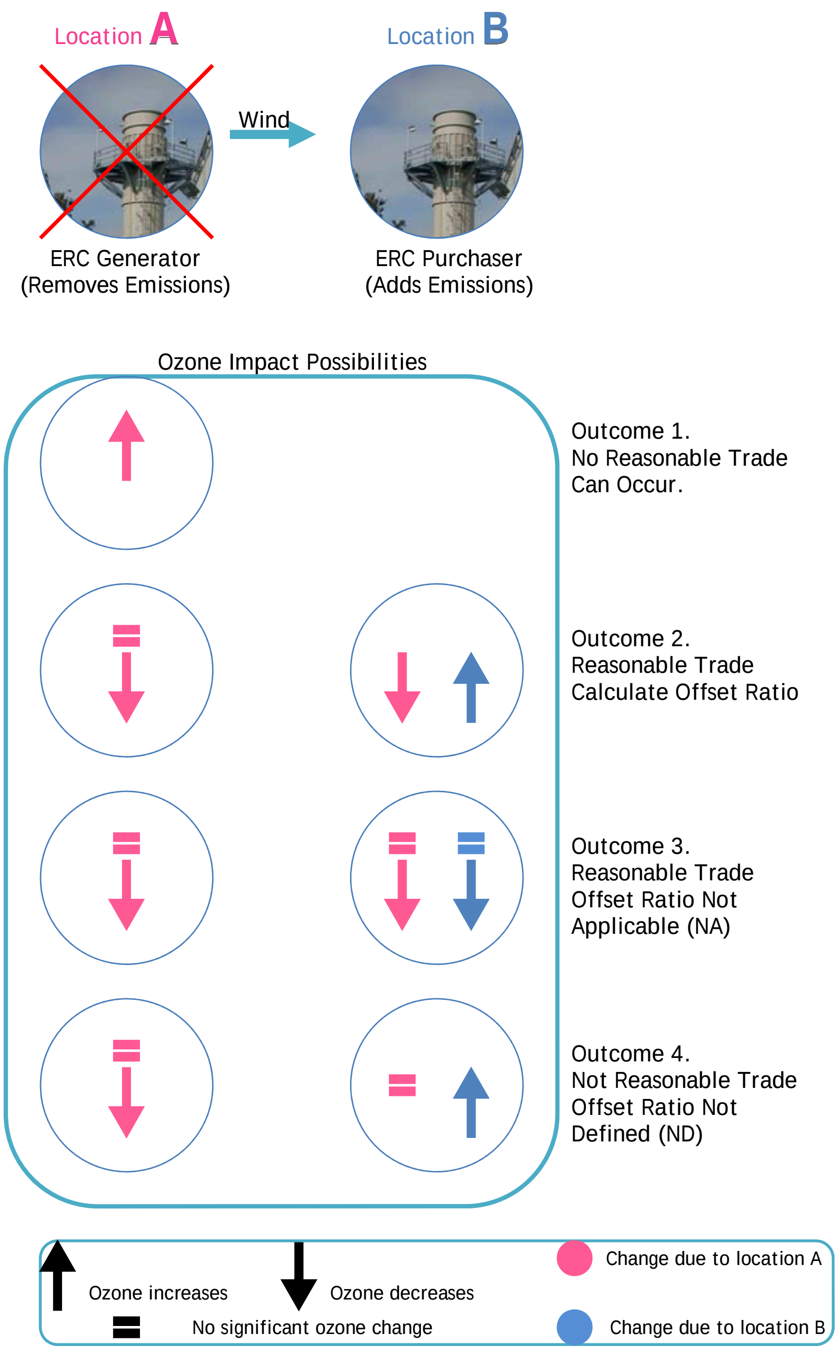
The assessment of ozone impacts of trading scenarios must be looked at as the culmination of two components:

- The impact of removing emissions from a source at location A (ERC generator)
- The impact of adding emissions from a power plant at location B (ERC user)

The four possible outcomes of these two components are shown in Figure 12. At first glance, it may seem counterintuitive to think that removing emissions at location A may increase ozone levels nearby (Outcome 1). However, as explained in the previous section, because ozone is a complex reaction that relies on the relative ratio of NOx to VOC, a decrease in NOx may actually cause an increase in ozone. This is termed the *disbenefit artifact,* due to titration effects as discussed in other sections. Alternatively, there may be situations where increasing NOx emissions can cause decreases in ozone concentrations. While this may be real, any pollution decrease due to increases in NOx is not reported and is listed as zero impact (Outcome 3). This is because increasing NOx is not considered a viable ozone reduction strategy for many reasons.

In the situation where changes in location A does not have any impacts downwind as far as location B, an offset ratio cannot be defined (Outcome 4). Recall that the offset ratio is the relative amount of emissions that need to be removed from location A to “offset” any increase from impacts at location B. If location A does not have any impact downwind, there is no need for an offset ratio at all. Finally, there is the classic trading scenario (Outcome 2), where emissions removed in a region mitigate the emissions added downwind. Here an offset ratio can be calculated.

Figure 12. Schematic of the Possible Outcomes of a Credit Trade



For each trading scenario, the modeling scenario calculation can be described as follows: The effects on ozone concentrations are first examined assuming **a one-to-one** trade (offset ratio = 1) i.e., simultaneously "remove" 10 power plants from Area A (i.e., Area A creates saleable ERCs) and "add" 10 power plants in Area B (i.e., Area B buys ERCs from Area A). The scenario is symbolized as A→B. Simulations were generated to represent before-and-after trade cases and a neutral case:

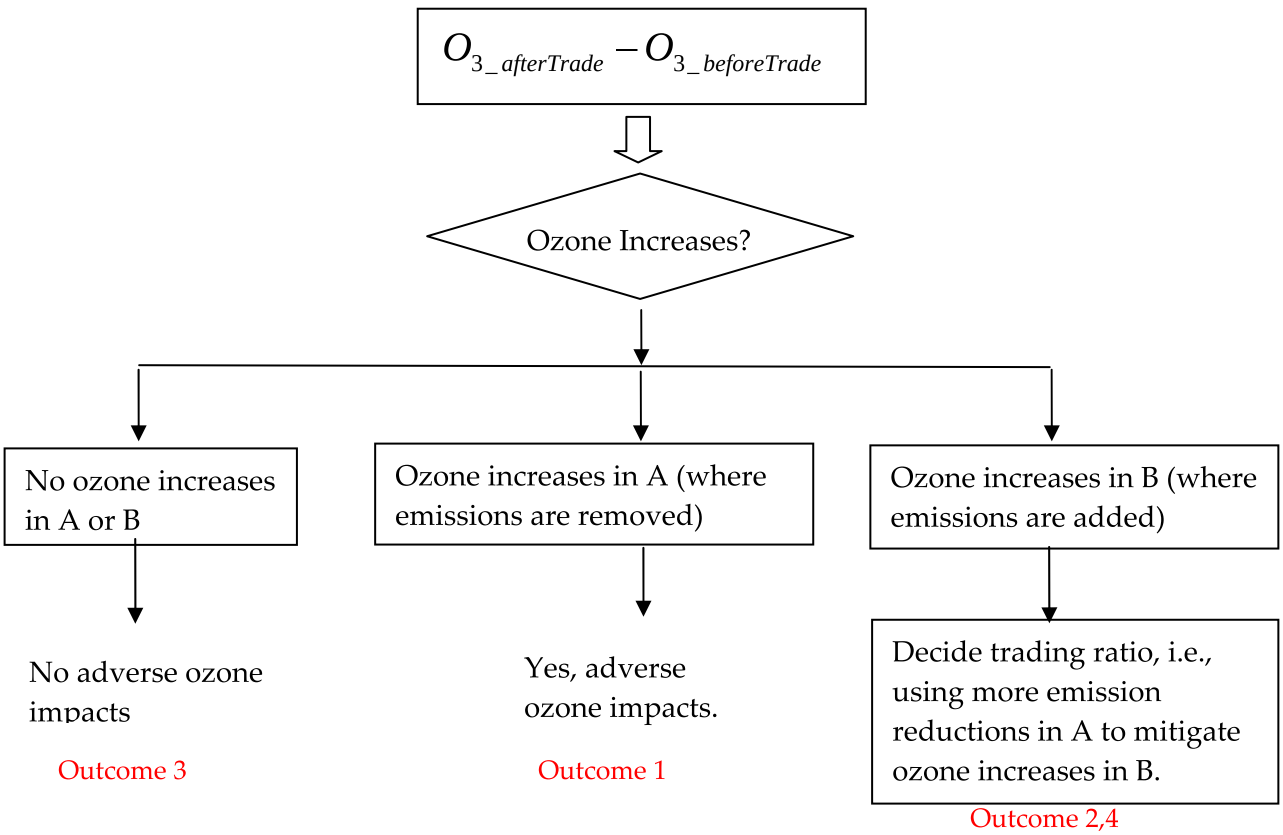
Before Trade	**After Trade**
10 power plants at A, 0 power plants at B	0 power plants at A, 10 power plants at B

Neutral Case
0 power plants at A, 0 power plants at B.

The ozone effects of this scenario are calculated by:

$$O_{3\_afterTrade} - O_{3\_beforeTrade}$$

The assessment then follows the flow chart:



The concept of offset ratio (OR) is not applicable (NA) to the left and center portions of the above diagram (Outcomes 1 and 3). In the case of the right side of the diagram, the offset ratio needs to be calculated. To decide the offset ratio (also called *trading ratio*), we calculate the ozone decreases induced by removing 10 power plants from A, i.e., the net effects of removing power plants, which will become the denominator of the offset equation: Ozone change at Area B from emissions changes at Area A) =

$$O_{3\_neutralCase} - O_{3\_beforeTrade}$$

and ozone increases induced by adding 10 power plants to B, i.e., the net effects of adding power plants, which will become the numerator in the offset equation: Ozone change at Area B from emissions changes in Area B =

$$O_{3\_afterTrade} - O_{3\_neutralCase}$$

The offset ratio is calculated by: $\dfrac{(O_{3\_afterTrade} - O_{3\_neutralCase})_{\max}}{(O_{3\_beforeTrade} - O_{3\_neutralCase})}$

The ozone concentration at the receiving site that results from the plant at the subtracting site is the denominator of the offset ratio equation.

Consequently, emission trading is justified only for two cases: (1) emission reductions in the ERC-generating air basins (location A) really mitigate the impact of the increased source emissions, or (2) both locations do not generate net ozone increases by adjusting emissions (such as in the Bay Area case). In the first case, a trading ratio is calculated for offsetting the source's increases in ozone (if significant— i.e., above 1 ppb) with the emission reductions in the ERC generating air basin**.**

It was assumed that modeled ozone changes of less than 1 ppb are so uncertain that there is no measurable signal. Therefore, any change with a magnitude less than 1 ppb is insignificant, and the offset ratios associated with these changes are not defined. The terms "No significant ozone increase" and "No ozone increase" are used interchangeably in our assessment.

In the model runs, the daily 8-hr ozone maxima for the simulation period are averaged over the weekdays. The maximum 8-hr ozone levels in the majority of the SJV, SFB, and Sacramento metropolitan areas are well above 70 ppb, and the remainder of the maximum ozone levels are mostly above 60 ppb. The federal 8-h ozone standard was revised to 75 ppb in 2008, and California has adopted an even more stringent standard of 70 ppb since 2005 as a result of special consideration for children's health. Considering the current ozone status in Central California, any increase of ozone levels is likely to lead to further nonattainment and thus should be avoided.

3.2 Results

Table 19 summarizes this study's findings on each trading scenario, followed by more detailed explanations of each scenario.

Table 19. Inter-basin Trading Scenario Results

Trade Scenario	Reasonability Test					Current Regulatory Feasibility Test***		
ERCs Area 1 → Area 2 (subtract emissions → add emissions)	Does Area 1 have available NO_x ERCs?	Does Area 2 need power plants?	Offset ratios	Would this trade result in significant ozone increases locally and downwind?*	Is this a reasonable trade?**	Rule 1. Worse non-attainment	Rule 2. Overwhelming impact (Does the air travel from A to B?)	Is this a feasible trade under current rules?
SAC → SFB	Yes	Yes	NA	No	Yes	Yes	sometimes	maybe
SFB → SAC	Yes	Yes	ND	Yes	No	No	Yes	No
SJV→ SFB	Yes	Yes	NA	No	Yes	Yes	No	No
SFB → SJV	Yes	Yes	ND	Yes	No	No	Yes	No
SAC → SJV	Yes	Yes	ND	Yes	No	No	Yes	No
SJV → SAC	Yes	Yes	NA	Yes	No	Yes	No	No

* Currently, considering only increased emissions from 10 power plants, non-lofted, and no reduced emissions at ERC site (assume not to have significant impact). ND indicates that the offset ratio is not defined, and NA means not applicable.

** *Reasonable trade* means that it is a needed, theoretically possible trade that does not show adverse ozone impacts (defined as resulting in ozone increases). The answer is yes if column 1 and 2 are yes and column 4 is no.

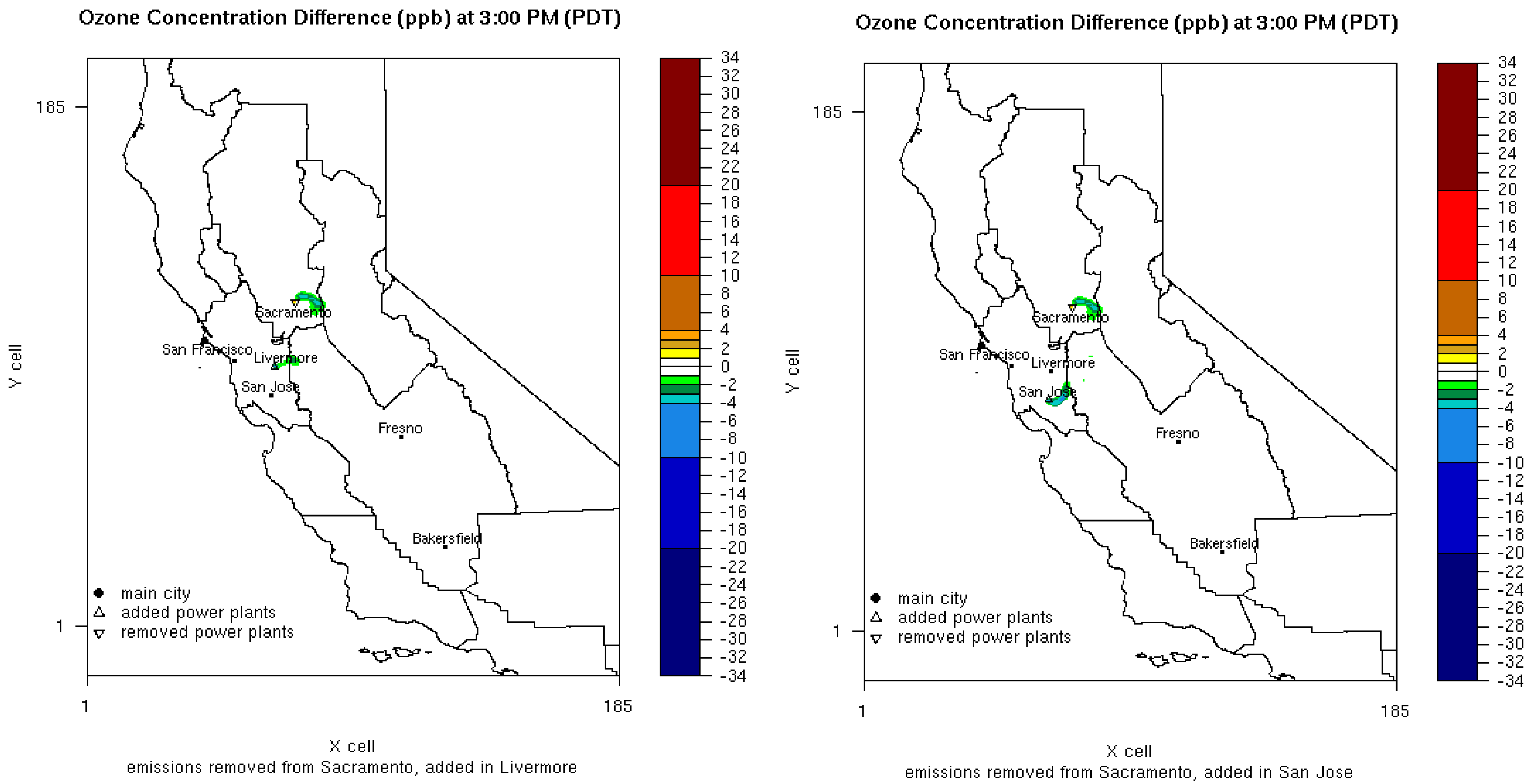
*** Does the trade comply with Rule 1 and Rule 2? Refer to the Rule discussion in Section 2.3.

3.2.1 Case1. Sacramento → San Francisco Bay Area

Figure 13 shows a 3:00 p.m. spatial map where the same 10 plants were simultaneously "removed" from Sacramento and "added" to the Bay Area, either at Livermore or San Jose. As shown in Appendix A, Figures A-1 and A-2, the surroundings of Livermore and San Jose are still NO_x disbenefit zones, leading to ozone decreases downwind (between 1 and 5 ppb); whereas Sacramento has nearby downwind NO_x benefit areas, where NO_x emission reduction reduces ozone (between 1 and 4 ppb).

This trade, removing NOx from Sacramento and adding it to the Bay Area, results in no significant ozone increase at either location, and may result in ozone decreases (Outcome 3). For example, the nearby areas downwind of Sacramento, Livermore, and San Jose exhibit ozone decreases in the middle of the afternoon, when ozone levels are the highest.

Figure 13. Ozone Concentration Difference Case 1:SAC→SFB



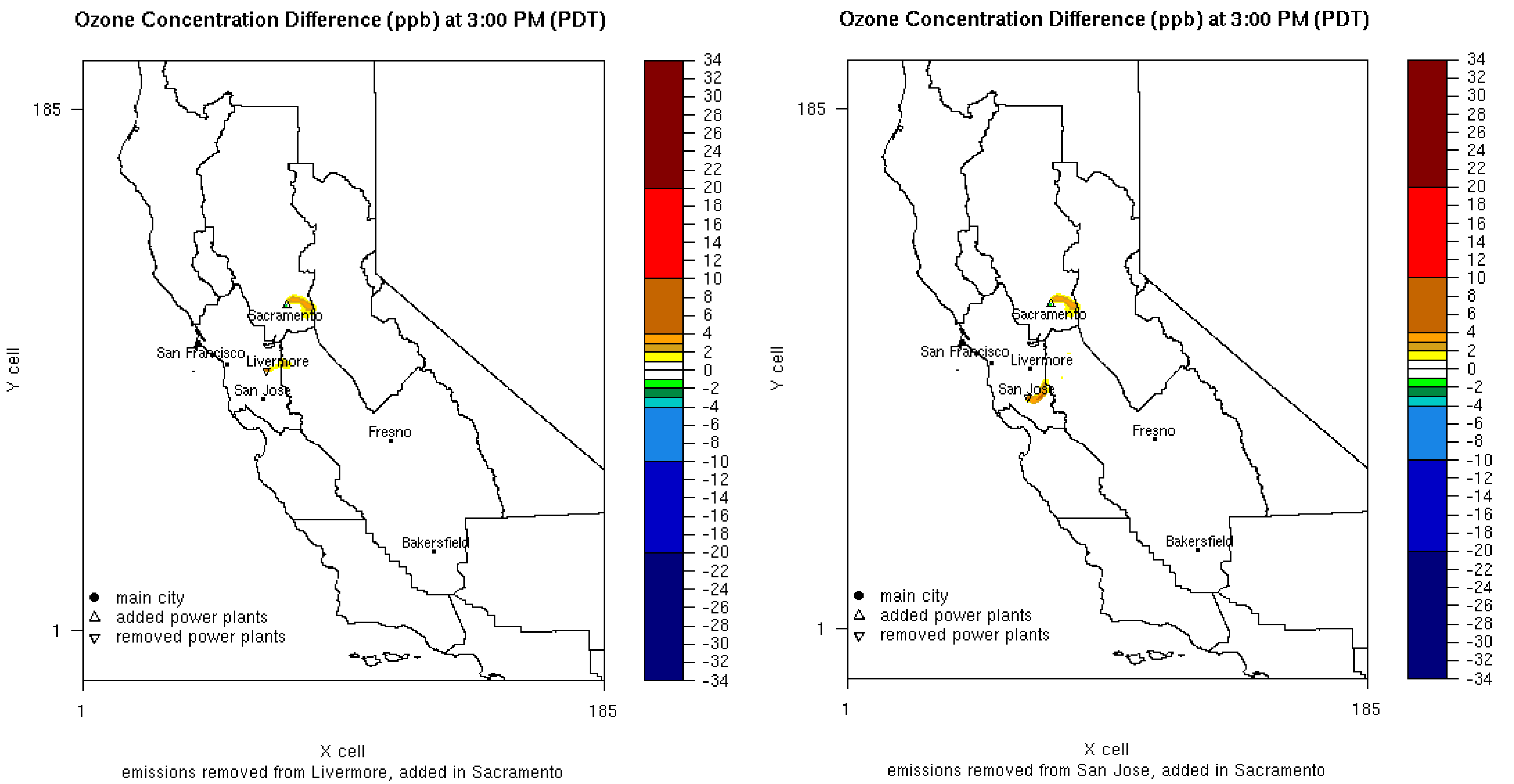
Shown on August 2 at 3:00 p.m. for "removing" the emissions equivalent to 10 base loaded power plants from Sacramento (grid cell (73,116)) and adding the same to the San Francisco Bay Area: Left: Livermore (grid cell (66,93)); Right: San Jose (grid cell (65,83))

3.2.2 Case 2. San Francisco Bay Area → Sacramento

This trading scenario is opposite to Case 1, and the changes in ozone concentration can be determined from Figure 13 by reversing the sign (i.e., decreases become increases with the same magnitude). In Case 2, Figure 14, ozone increases occur downwind from both Sacramento and the SFB locations. The Bay Area emissions (10 base loaded power plants) have an insignificant impact (less than 1 ppb) on ozone levels in Sacramento. The offset ratio associated with this case cannot be defined. Removing power plants from the Bay Area is not able to offset the ozone increases (~ 3 ppb) caused by the power plants (10 base loaded power plants) placed in Sacramento. Removing emissions from the Bay Area is likely to result in ozone increases because, at most locations, the local ozone chemistry regime is in a NOx disbenefit regime.

In summary, this trade will increase emissions locally (NOx disbenefit) in the SFB area (falling under Outcome 1 in Figure 12), therefore no trade should occur.

Figure 14. Ozone Concentration Difference Case 2: SFB→SAC



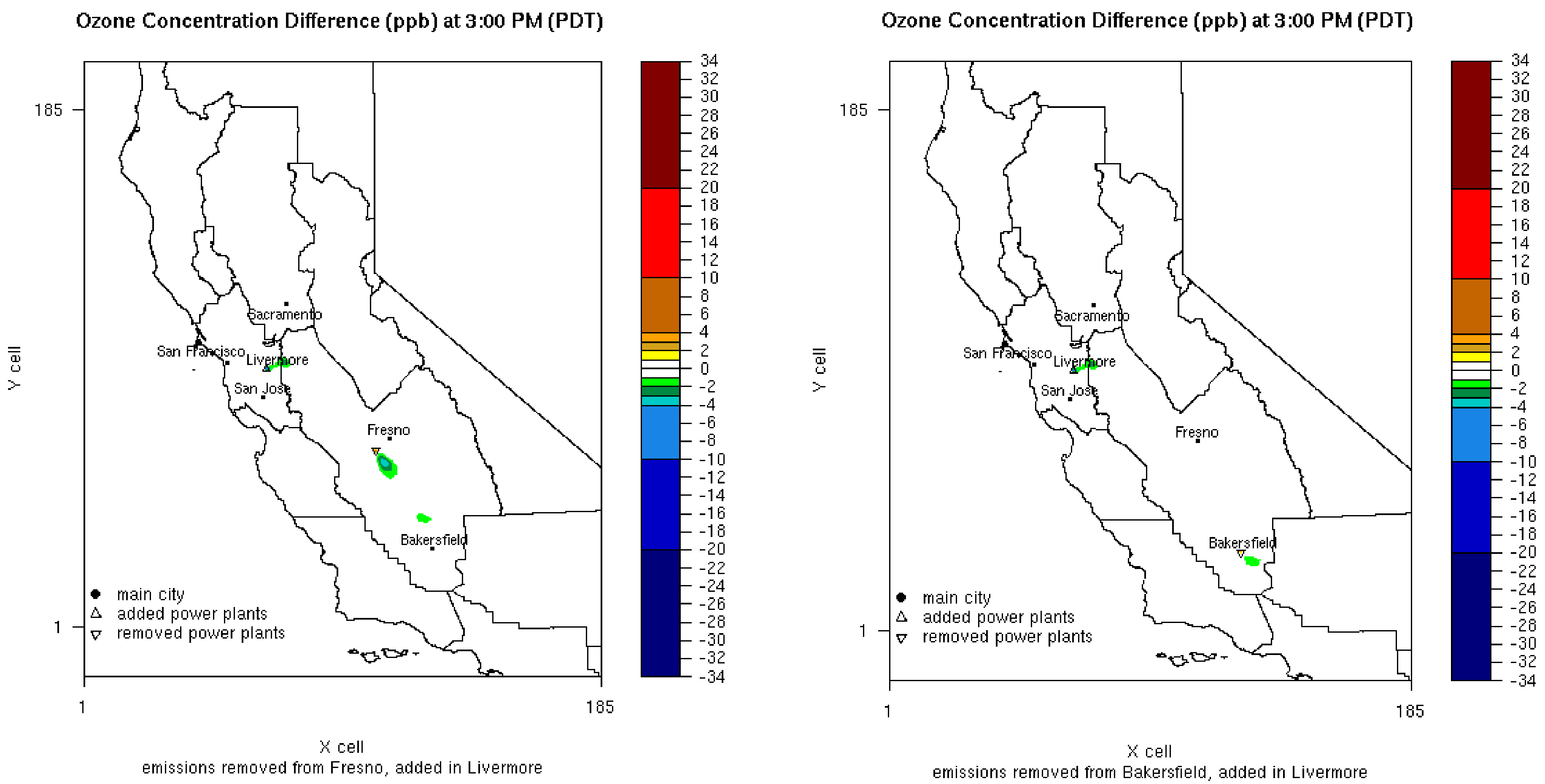
Shown on August 2 at 3:00 p.m. for "removing" the emissions equivalent to 10 base loaded power plants from the San Francisco Bay Area and adding the same to Sacramento (grid cell (73,116)): Left: Livermore (grid cell (66,93)); Right: San Jose (grid cell (65,83))

3.2.3 Case 3. San Joaquin Valley → San Francisco Bay Area

Livermore is in the Bay Area, and was selected because it is responsible for greater ozone changes downwind (according to our previous analysis) than other SFB locations, therefore it is more likely to have an impact on the SJV. Here and in the following, the power plants designated in Fresno County are located in the the rural NO_x benefit area southwest of the city of Fresno. We use "Fresno" as the source name, even though the power plants are located southwest of the city. The plants in Kern County are located exactly at the Bakersfield grid cell.

In terms of results shown in Figure 15, this scenario is similar to Case 1 (Figure 13). When emissions are removed at "subtracting" locations (Fresno or Bakersfield) that are surrounded by NOx benefit areas (like Sacramento), ozone decreases downwind (up to 3.6 ppb and 1.7 ppb, respectively). Emissions given to "receiving" cities like Livermore and San Jose that are located in strongly NOx disbenefit areas cause decreases in ozone in downwind areas. The conclusion is the same as that for Case 1: This trade falls under Outcome 3, where the trade removing NOx from the SJV and adding it to the Bay Area results in no significant ozone increase at either location, and may result in ozone decreases.

Figure 15. Ozone Concentration Difference Case 3:SJV→SFB



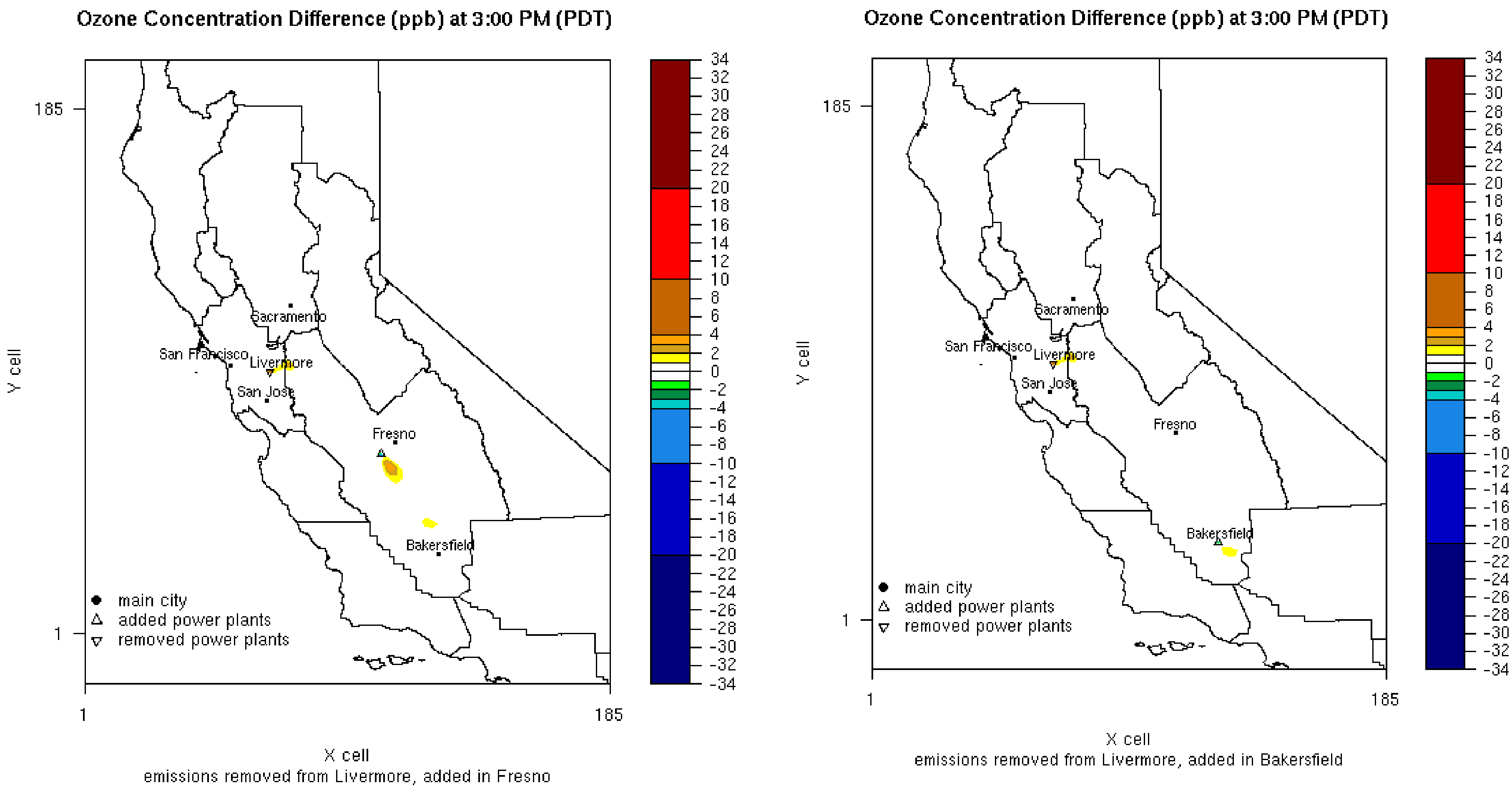
Shown on August 2 at 3:00 p.m. for "removing" the emissions equivalent to 10 base loaded power plants from the San Joaquin Valley (Fresno or Bakersfield) and adding the same to the San Francisco Bay Area (Livermore, (grid cell (66,93)). Left: emissions "removed" from Fresno (grid cell (105,64)); Right: emissions "removed" from Bakersfield (grid cell (125,29)).

3.2.4 Case 4. San Francisco Bay Area → San Joaquin Valley

If we remove emissions from the SFB (i.e., Livermore) and add the same amount in the SJV (either in Fresno or Bakersfield), we see that ozone increases occur downwind of the "subtracting" and "receiving" sources (Figure 16).

Bay Area emissions (in this case, 10 base loaded power plants in Contra Costa County) have an insignificant ozone impact on Fresno or Bakersfield. The increased ozone noted for Fresno and Bakersfield in Figure 16 is due to the emissions added nearby; and as explained in Section 3.1.2, when there is no impact from Area A to B there is no defined offset ratio for the case. Although SJV is downwind of the Bay Area, in this scenario reducing Bay Area emissions does not offset ozone increases in SJV insofar as Fresno or Bakersfield. Furthermore, this trade results in ozone increases in both the Bay Area and SJV; the Bay Area from removing local NOx and the SJV from adding local NOx. This trade is not conducive because it follows Outcome 1.

Figure 16. Ozone Concentration Difference Case 4: SFB→SJV



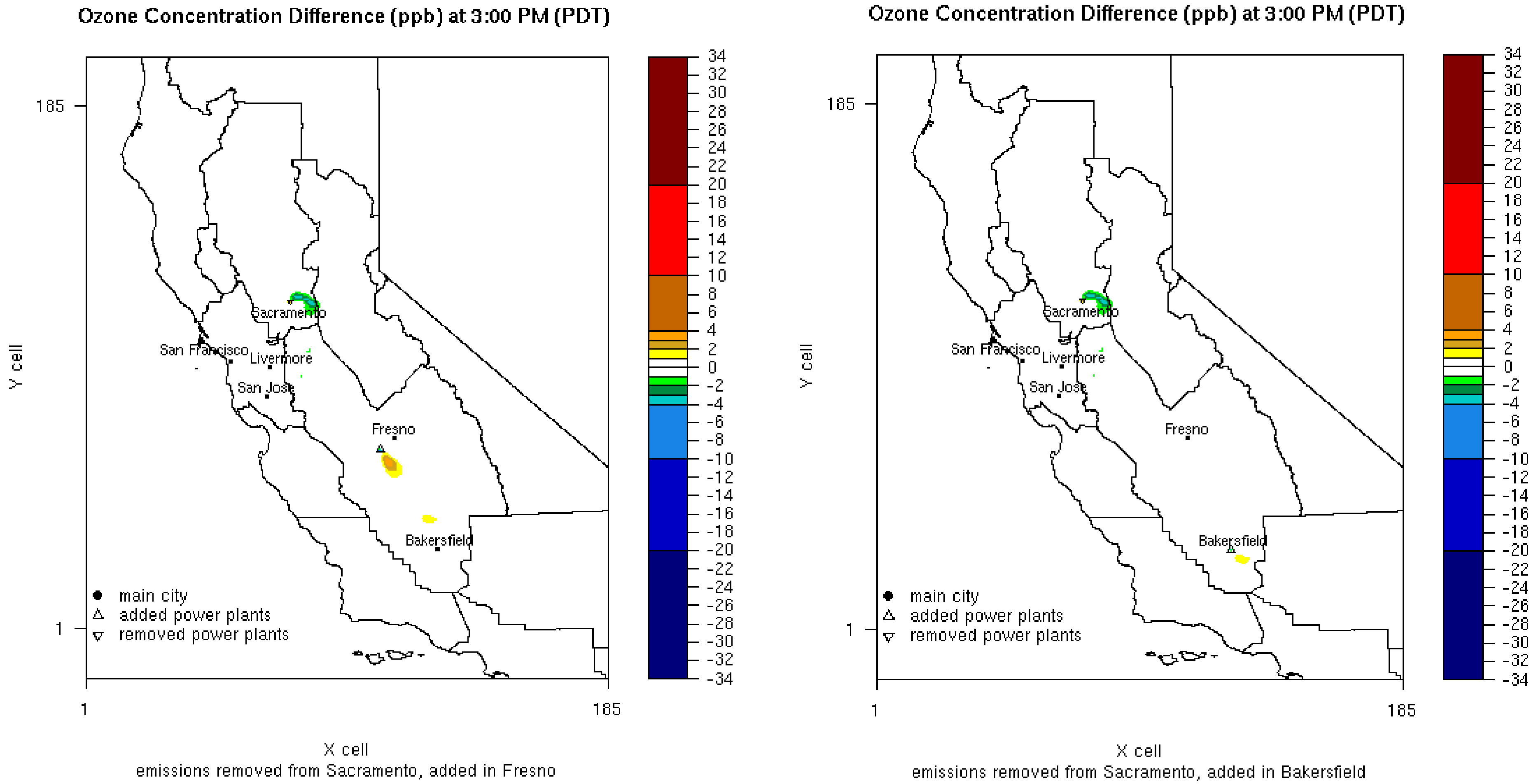
Shown on August 2 at 3:00 p.m. for "removing" the emissions equivalent to 10 base loaded power plants from San Francisco Bay Area (Livermore, (grid cell (66,93)) and adding the same to San Joaquin Valley (Fresno or Bakersfield). Left: emissions "added" to Fresno (grid cell (105, 64)); Right: emissions "added" to Bakersfield (grid cell (125,29)).

3.2.5 Case 5. Sacramento → San Joaquin Valley

Figure 17 shows that “subtracting” the emissions equivalent to 10 base loaded power plants from Sacramento and “adding” them to the SJV would lead to ozone decreases in Sacramento (~ 3 ppb) and increases (~3 ppb) in the SJV.

Perturbed Sacramento emissions (addition or subtraction of 10 base loaded power plants) have an insignificant ozone impact (less than 1 ppb) in Fresno, therefore an offset ratio cannot be defined. In other words, Although the SJV is downwind of Sacramento, emissions changes in Sacramento in these scenarios do not have any impact on ozone changes in SJV. The increase in SJV ozone observed is due entirely to placing the 10 base loaded power plant emissions near the SJV cities. In this trading scenario, there is always an ozone increase in SJV and decreases in Sacramento (Outcome 4).

Figure 17. Ozone Concentration Difference Case 5: Sac→SJV

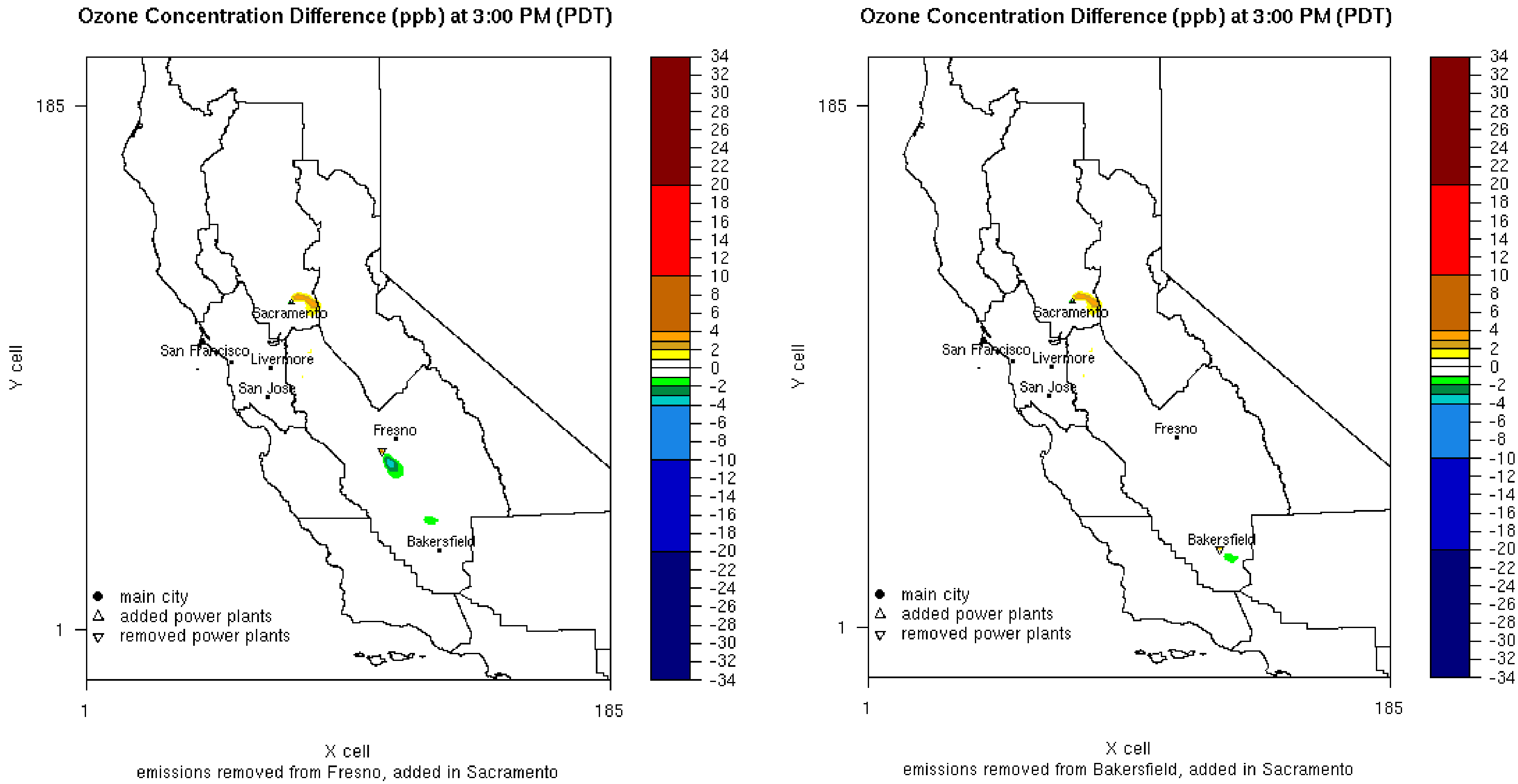


Shown on August 2 at 3:00 p.m. for "removing" the emissions equivalent to 10 base loaded power plants from Sacramento (grid cell (65,83)) and "adding" the same to the San Joaquin Valley. Left: emissions "added" to Fresno (grid cell (105, 64)); Right: emissions "added" to Bakersfield (grid cell (125,29)).

3.2.6 Case 6. San Joaquin Valley → Sacramento

The direction of the NOx trades associated with Case 5 is reversed for the Case 6 trade. The results are shown in Figure 18, where ozone concentrations in areas downwind of the sources are decreased in the SJV and increase near Sacramento. Sacramento is not a downwind air basin of the SJV, and reducing SJV emissions cannot offset ozone increases in Sacramento. In this trading scenario, there is always an ozone increase in Sacramento (Outcome 4).

Figure 18. Ozone Concentration Difference Case 6: SJV→Sac



Shown on August 2 at 3:00 p.m. for "removing" the emissions equivalent to 10 base loaded power plants from the San Joaquin Valley and adding the same to Sacramento (grid cell (65,83)). Left: emissions "removed" from Fresno (grid cell (105, 64)); Right: emissions "removed" from Bakersfield (grid cell (125,29).

.

3.3 Discussion

The six interbasin trades analyzed are summarized in Table 20. To model the interbasin trades, emissions were added to the power plant location and subtracted from the source location. The impact on ozone was observed. Because the power plant emissions are so low compared to the rest of the inventory, they were multiplied by a factor of 10 in the model. Additionally, emissions from ten peaker plants did not cause a significant impact on ozone. Therefore the results presented here are for 10 base loaded power plants. Table 21 provides the results.

Table 20. Interbasin Trades Modeled

Case	Power Plant Location	Source of ERCs
1	SF Bay Area (Livermore & San Jose)	Sacramento Metro
2	Sacramento Metro	SF Bay Area (Livermore & San Jose)
3	SF Bay Area (Livermore & San Jose)	San Joaquin Valley (Fresno & Kern)
4	San Joaquin Valley (Fresno & Kern)	SF Bay Area (Livermore & San Jose)
5	Sacramento Metro	San Joaquin Valley (Fresno & Kern)
6	San Joaquin Valley (Fresno & Kern)	Sacramento Metro

Table 21. Air Quality Modeling Results

Case	Effect in Power Plant Location	Effect in ERC Source Location
1	No Ozone Increase	No Ozone Increase
2	Ozone Increase	Ozone Increase
3	No Ozone Increase	No Ozone Increase
4	Ozone Increase	Ozone Increase
5	Ozone Increase	No Ozone Increase
6	Ozone Increase	No Ozone Increase

For Cases 1 and 2, the local areas downwind of the SF Bay Area power plants are NOx disbenefit areas. Therefore, when a power plant is added, the ozone decreases (Case 1) and when emissions are removed, ozone increases (Case 2). The local area downwind of the Sacramento power plant is NOx benefit. Therefore, when a power plant is added, ozone increases (Case 2) and when emissions are removed, ozone decreases (Case 1). Also, in Case 1 it was found that SF Bay power plant emissions have a negligible impact on ozone formation in Sacramento.

Cases 3 and 4 are similar to Cases 1 and 2. Adding NOx emissions to the SF Bay Area decreases ozone, removing emissions (ERCs) increases ozone. In San Joaquin Valley, the plants are located in NOx benefit regions, so removing emissions is beneficial, while adding emissions increases ozone.

In Cases 5 and 6, both regions have NOx benefit characteristics downwind of the power plant locations. Therefore, if a power plant is installed, ozone increases. Conversely if emissions are removed, ozone decreases.

In summary, the only interbasin trading scenarios found to be beneficial within the modeling domain (in terms of ozone formation) are to utilize ERCs from either Sacramento or San Joaquin Valley to offset emission increases in the San Francisco Bay Area. Neither of these trades is allowed by current federal/state trading rules.

As mentioned earlier, this modeling exercise was not intended to be a comprehensive analysis of interpollutant/interbasin trading. Rather it was meant to be a quick first look to see if current rules are over constraining. We found that two interbasin trades are environmentally benign from an ozone standpoint even though these two trades are not allowed under current policies.

Because of different NO_x sensitivity regimes, trading among these locations almost always leads to increases in ozone somewhere. Keep in mind that these are trades that were analyzed using the predominate meteorological data from the entire season, not just a single day. Since most of the region experiences ozone levels above the state and federal standards, any ozone increases should be avoided. Simulations have shown that ozone increases are small, approximately 1 ppb per 500 MW added capacity. Unfortunately, offset ratios are not defined for these trades because the denominator in the offset ratio equation is less than 1 ppb and represents an ozone change that is encumbered with large uncertainties. In other words, ozone increases are mostly detectable, but the model cannot detect the ozone decreases at the "receiving" locations caused by the reduced emissions from the credit generating locations. In short, the trades analyzed did not see any impact from the other locations involved. Therefore, this exercise for developing overarching policy recommendations is limited.

If further work in this area is done, the following elements are recommended for consideration in future analysis:

1. **Update the modeling year:** An important factor in determining the impacts of ozone on areas is the magnitude and ratio of the NO_x and VOC emissions inventory and their respective sensitivity regimes. The year 2000 was used in this investigation. Recent rulemaking will reduce NO_x emissions dramatically over the next decade across the state and this impact should be included in any modeling analysis used to support rulemaking development. Power plants in California are operated with natural gas, with technology improvements, and have very few emissions relative to mobile source emissions; especially NO_x from diesel trucks. By reducing NO_x more significantly than VOCs, the valley will shift more toward a NO_x-limited regime, and "hot spots" like Bakersfield and Fresno and their urban cores would expect that additional NOx in the region is likely to produce more ozone. This changing inventory should be taken into account if new simulations are conducted.

2. **Conduct trades in different regions:** Only Central California was investigated, but there could be opportunities for other areas, such as the South Coast Air Basin.

3. **Conduct trades for other pollutants related to PM:** The modeling for this study was limited to VOC and NO_x; however, modeling of PM and PM precursors is also recommended.

4. **Conduct trades for VOC:** This study is focused on NO_x as an ozone precursor because VOC emissions from power plants are very small compared to NO_x emissions (about six times less on a mass basis). An alternative trading program for VOCs could be considered, especially in the case of VOC-limited regime (i.e., NO_x disbenefit areas). Volatile organic compounds react more slowly (and thus over longer distances) than NO_x. Trading VOC for NO_x on a short-term basis could be a possibility, as long as distances and specificities in time, meteorology and locations are taken into consideration. Needless to say, this inter-pollutant trading requires careful analysis.

5. **Conduct trades within closer distance:** It has to be noted that the simulations conducted show that the "subtracting" and "receiving" areas do not affect each other. Trades closer together may offer some different results.

6. **Conduct trades on different meteorological scenarios:** In other work by LBNL, it has been shown that it is possible to predict the ozone impacts for most days throughout the season by defining half a dozen meteorological regimes that could be modeled. This would be an important item to include in a full-scale analysis, to determine the net effect of the seasonal or annual trade.

7. **Refine modeling methodology:** In consultation with ARB and air districts, define strategy and metrics for success. Consider variations among years, emission trends, limiting pollution regimes, and other factors.

CHAPTER 4: Market Analysis of Cost and Supply of Potential ERCs

The purpose of this task was to test the hypothesis that the prospects for power plant permitting could be improved in certain air districts if additional types of ERCs were made available. The analysis focused on three air districts with the most constrained supplies of ERCs: the South Coast AQMD, San Diego APCD, and Sacramento Metropolitan AQMD. Two different types of trades were considered: interpollutant trades and interdistrict trades. A short-term trade labeled *multi-facility bubbling* was also considered briefly.

4.1 Methodology

4.1.1 Approach

The premises of this market analysis are as follows:

1. Power plant permitting is made more challenging by the lack of certain ERCs.
2. The problem could be alleviated if additional ERCs were made available as the result of more flexible rules governing inter-pollutant, inter-district, and multi-facility bubbling.

The two example power plants utilized in the air quality modeling analysis were utilized here. The hourly emissions were translated into annual tonnage by assuming that the base loaded plant would be permitted at 100 percent capacity factor while the peaker would seek sufficient ERCs to operate at a 10 percent annual capacity factor. The amount of ERCs would be needed equivalent to the "actual emissions" provided in Table 22 below.

Table 22. Hypothetical Power Plant Offset Requirements

	Plant Hourly Emissions, lb/hr			Maximum Daily Emissions, lb/day			Annual Emissions tons/yr[17]		
	NOx	VOC	PM_{10}	NOx	VOC	PM_{10}	NOx	VOC	PM_{10}
Base Loaded Natural Gas Combined Cycle 500 MW	38	7	28	910	168	662	166	31	121
Peaker*, Natural Gas Simple Cycle 150 MW	24	4	10	169	26	70	10	2	4

* Peaker emissions assume 7 hours/day, June–Sept

[17] No offset ratios are considered.

Therefore, the following ERCs were assumed to be needed for the hypothetical power plants:

- NOx (166 tpy for base load and 10 tpy for peaker)
- VOCs (31 tpy and 2 tpy)
- PM_{10} (121 tpy and 4 tpy)

The supply and demand for select ERC markets in the following air districts were identified:

- **South Coast Air Quality Management District (SCAQMD).** There is a severe shortage at present of PM_{10} ERCs in the SCAQMD. Demand is higher than supply—most of the demand is from seven power plant projects. CantorCO2e estimated the supply and cost of substituting reactive organic gases (ROG), NOx, and SO_2 ERCs for PM_{10} emissions. With the exception of SO_2 for PM_{10} trades conducted on a case-by-case basis, these trades are not currently made.
- **San Diego County Air Pollution Control District (SDAPCD).** There is a shortage of NOx and VOC emission reduction credits in the San Diego APCD. CantorCO2e estimated the supply and cost of interbasin trades of NOx and VOC emission reduction credits from SCAQMD. This interbasin trade is allowed by current state and federal rules. However, interbasin/interdistrict trading is explicitly forbidden by SDAPCD rules.
- **Sacramento Metropolitan Air Quality Management District (SMAQMD).** There is a shortage of NOx and VOC emission reduction credits in the Sacramento Metropolitan AQMD. CantorCO2e estimated the supply and cost of interbasin trades of NOx and VOC emission reduction credits from San Joaquin Valley to offset Sacramento NOx and VOC emissions. This trade is not allowed by federal or state ERC rules.

Recognizing that regulators would likely demand that an offset ratio be applied, as a means of conducting a sensitivity analysis, three offset ratios have been applied to the evaluated scenarios: 2:1, 15:1, and 30:1. The actual ratios will be defined in the rules and policies as interpreted by the district staff with input from the facilities. While it is possible that the ratios could be higher or lower, it is also possible that the contemplated trades will not be allowed under any ratio (or circumstances).

The contractor identified shortfalls of ERCs that are critical to the development of power plants (i.e., situations where supplies of ERCs fall far short of demand or are available only at prices that make their acquisition uneconomic). Then, the feasibility of using the following flexible trading mechanism as a means to alleviate ERC shortfalls for inter-pollutant trading, interdistrict trading, and multifacility bubble trading was evaluated.

Inter-Pollutant Trading

Inter-pollutant trading is defined here as substituting ERCs of precursor pollutants for the pollutant being emitted (e.g., substituting VOC, NOx, and/or SO_2 emission reduction credits for PM_{10} emissions and substituting NOx emission reduction credits for VOC emissions and/or

VOC emission reduction credits for NOx emissions when required as ozone precursors). This study considered the impact of using inter-pollutant trading in the SCAQMD.

Inter-District Trading

Inter-district trading is defined here as offsetting emissions using ERCs that originate in a district other than the air district within which the new source is located. This study considered the impact of using inter-district trading between:

- SDAPCD using NOx emission reduction credits from the SCAQMD
- SDAPCD using VOC emission reduction credits from the SCAQMD
- SMAQMD using NOx emission reduction credits from San Joaquin Valley APCD
- SMAQMD using VOC emission reduction credits s from San Joaquin Valley APCD

Multi-facility bubble trading

Multi-facility bubble[18] *trading* is defined here as offsetting emissions that occur at a facility by curtailing emission at another facility during the same time period. For example, allowing a source to increase its emissions by 2 lbs/day on a particular day by causing a second source to curtail its emissions by 2 lbs/day. Insufficient data were available to complete the feasibility of using bubbling as a means to alleviate ERC shortfalls.

4.1.2 Key Assumptions

This analysis includes the assumption that a change in the rules allowing inter-pollutant, inter-district, and multi-facility bubbling trading would:

- alleviate supply problems in these air districts;
- not adversely diminish the supply of ERCs;
- be allowed without delay by the relevant air districts;
- not be opposed by the U.S. EPA, ARB, or nongovernmental organizations (NGOs); and
- not result in issued permits being challenged and/or held in abeyance by third parties.

When an offset ratio between 2:1 and 30:1 is required by the air district before the flexible (i.e., interpollutant) trading mechanism can be used, this was applied in the analysis. For example, in the SCAQMD, if a 30 ROG to 1 PM_{10} ratio is required, this means that 30 lbs/day of ROG emission reduction credits are required to offset each 1 lb/day PM_{10} increase. No attempt was made to determine what exact ratio, if any, would be appropriate.

---

[18] The term *bubble trading* refers to the idea that an entire industrial complex represents one source, with no distinction of individual sources within the overall complex. The source may have multiple emissions releases or stacks but the entire facility is treated as one source or one "bubble." As long as the cumulative emissions from points within the bubble do not exceed the permitted bubble emissions, the facility is in compliance.

For offset ratios, the quantity of emissions to be offset is as stated below (and without an additional offset factor):

- NOx (166 tpy for base load and 10 tpy for peaker)
- VOCs (31 tpy and 2 tpy)
- PM_{10} (121 tpy and 4 tpy)
- ROG for PM_{10} (currently not done)
- NOx RTCs[19] for PM_{10} (currently not done)
- SOx for PM_{10} (currently done on a case-by-case basis)

4.2 Markets

This section describes the three regional markets that were considered. Included in each description is a summary of the supply, demand, and expected market clearing prices for ERCs that were considered as a part of this analysis, based on the expert opinions and information available to the contractor. Table 23 addresses the cost and feasibility of securing the critical ERCs within each district. [20]

[19] *RTC* stands for RECLAIM Trading Credits, which is a variety of ERCs specifically used for NOx from stationary power production sources in the South Coast Air Quality Management District under the RECLAIM trading program.

[20] This table also provides information about the feasibility of using some of the flexible trading mechanisms to address the critical ERC shortfalls.

Table 23. Summary Analysis—Supply and Cost Feasibility

District	ERC Limited	Potential Solution		Ratio	Will Inter-Trading Help? Quantity ERCs Required (tpy)			
					Low Quantity (expected cost)		High Quantity (expected cost)	
					Low Cost	High Cost	Low Cost	High Cost
South Coast AQMD	PM_{10} 4 and 121 tpy	SCAQMD PM_{10} for SCAQMD PM_{10}		1:1	$3,287,671	$8,767,123	$99,452,055	$265,205,479
		Bubbling with SCAQMD PM_{10} ERCs		NA	NA	NA	NA	NA
		Inter-pollutant with SCAQMD	with ROG	2:1	$306,849	$876,712	$9,282,192	$26,520,548
				15:1	$2,301,370	$6,575,342	$69,616,438	$198,904,110
				30:1	$4,602,740	$13,150,685	$139,232,877	$397,808,219
			with NOx (ERCs[21]/RTCs)	2:1	$6,221,829	$12,330,535	$188,210,340	$372,998,674
				15:1	$46,663,721	$92,479,010	$1,411,577,552	$2,797,490,057
				30:1	$93,327,441	$184,958,020	$2,823,155,104	$5,594,980,115
			with SOx	2:1	$3,287,671	$8,767,123	$99,452,055	$265,205,479
				15:1	$24,657,534	$65,753,425	$745,890,411	$1,989,041,096
				30:1	$49,315,068	$131,506,849	$1,491,780,822	$3,978,082,192
San Diego APCD	NOx 10 and 166 tpy	San Diego NOx (or 2 San Diego VOCs for 1 for NOx ratio) for San Diego NOx		1:1	$1,600,000	$1,750,000	$26,560,000	$29,050,000
		Inter-district with SCAQMD	NOx RTCs	2:1	$15,554,574	$30,826,337	$258,205,921	$511,717,190
				15:1	$116,659,302	$231,197,525	$1,936,544,410	$3,837,878,922

[21] Assume that RTCs can be converted to ERCs as follows:

((# RTCs in any given vintage x 0.775)/2000) = # tpy NOx ERCs

District	ERC Limited	Potential Solution		Ratio	Will Inter-Trading Help? Quantity ERCs Required (tpy)			
					Low Quantity (expected cost)		High Quantity (expected cost)	
					Low Cost	High Cost	Low Cost	High Cost
				30:1	$233,318,604	$462,395,051	$3,873,088,820	$7,675,757,844
Sacramento Metropolitan AQMD	NOx 10 and 166 tpy	Sacramento NOx for Sacramento NOx		1:1	$160,000	$290,000	$2,656,000	$4,814,000
		Inter-district with San Joaquin Valley	NOx ERC	2:1	$760,000	$1,380,000	$12,616,000	$22,908,000
				15:1	$5,700,000	$10,350,000	$94,620,000	$171,810,000
				30:1	$11,400,000	$20,700,000	$189,240,000	$343,620,000
	VOC 2 and 31 tpy	Sacramento VOC for Sacramento VOC		1:1	$18,000	$50,000	$279,000	$775,000
		Inter-district with San Joaquin Valley	VOC ERC	2:1	$50,000	$106,000	$775,000	$1,643,000
				15:1	$375,000	$795,000	$5,812,500	$12,322,500
				30:1	$750,000	$1,590,000	$11,625,000	$24,645,000

Key	
Feasible Supply and Cost	Insufficient Supply
Feasible Supply but not Cost	Unknown

4.2.1 South Coast AQMD

The SCAQMD emission reduction credit market is probably the most active criteria pollutant emission credit market in the United States. Table 24 provides a snapshot of the ERC and RTC market (as of November 1, 2009).

Table 24. SCAQMD ERC/RTC Market, November 2009

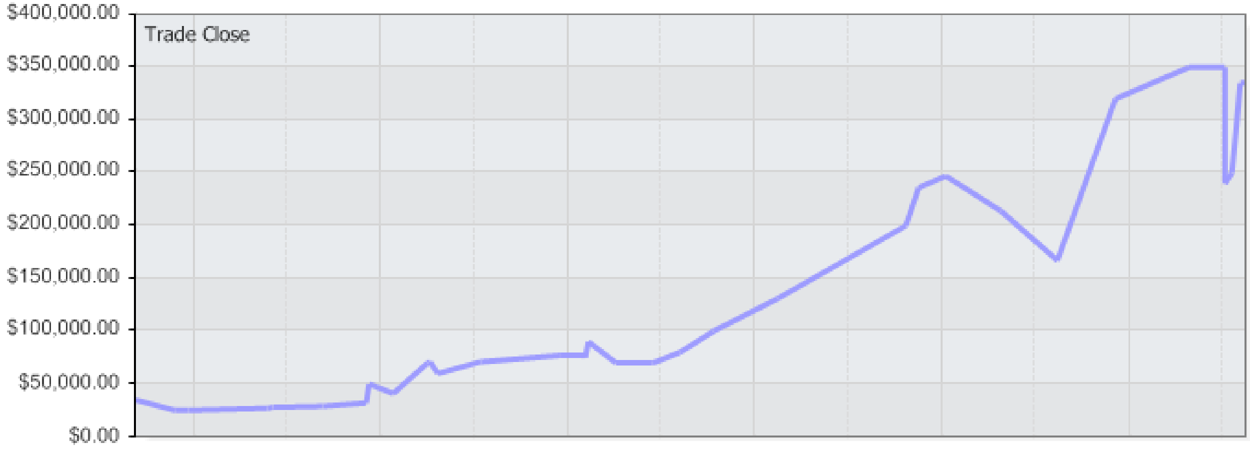
Credit Type	Supply	Demand	Low Range	High Range
			$/unit	$/unit
NOx RTC (lbs/day)	950,000	600,000	$ 55	$109
SOx RTC (lbs/day)	400,000	250,000	$25	$40
PM_{10} ERC (lbs/day)	248	> 1,000	$150,000	> $400,000
SOx ERC (lbs/day)	347	> 1,000	$75,000	> $200,000
ROG ERC (lbs/day)	4,000	1,500	$7,000	$20,000

As can be seen, the supply exceeds demand for PM_{10}. More than 1,000 lbs/day (182.5 tpy) are sought and, at best, only 248 lbs/day (45 tpy) could theoretically be secured. Most of this demand comes from seven power plants. Depending on the volume of the demand, location of the credit (i.e., inland versus coastal), and other factors, PM_{10} emission reduction credits could be secured for as little as $150,000/lb/day ($822,000/tpy) to **more** than $400,000/lb/day ($2,192,000/tpy).

To be clear, as there is an insufficient supply to satisfy the TOTAL demand, a true upper end of the price range cannot be provided. Hence, it would not be surprising if the highest marginal cost of acquiring PM_{10} emission reduction credits would cost more than $400,000/lb/day ($2,192,000/tpy).

Viewed through the lens of prices, the PM_{10} ERC supply-demand imbalance has been growing worse over the years. As shown in Figure 19, since 1999, prices have risen from $137,000/tpy ($25,000/lb/day) to higher than $1,172,000/tpy ($214,000/lb/day). Trades have posted as high as $1,918,000/tpy ($350,000/lb/day).

Figure 19. SCAQMD PM_{10} Price Chart from 11/1999 to 11/2009 ($/lb/day)



In SCAQMD at the present time, there is more demand for PM_{10} ERCs than supply—most of the current demand comes from seven power plant projects. However, there is sufficient supply for our example peaker plant. Figure 20 illustrates the results of interpollutant trading within SCAQMD to offset PM_{10} emissions from the peaker plant. The current market prices are shown for PM_{10} emission reduction credits as well as for ROG, NOx, and SO_2 emission reduction credits substituting for PM_{10} over the range of offset ratios. Results in green indicate that an interpollutant trade makes sense economically and sufficient substitute ERCs are available. Results in red indicate that the trade is not feasible, either because the price is higher than the actual PM_{10} emission reduction credits price or because there is insufficient supply of the substituting ERC (ROG, NOx, or SO_2). As can be seen, ROG for PM_{10} is a viable solution, except at the higher range of price and offset ratio. Substitution of NOx and/or SOx emission reduction credits at a 2:1 ratio is another viable option.

Figure 20. SCAQMD Peaker Plant Interpollutant Trade Transaction Cost Estimates

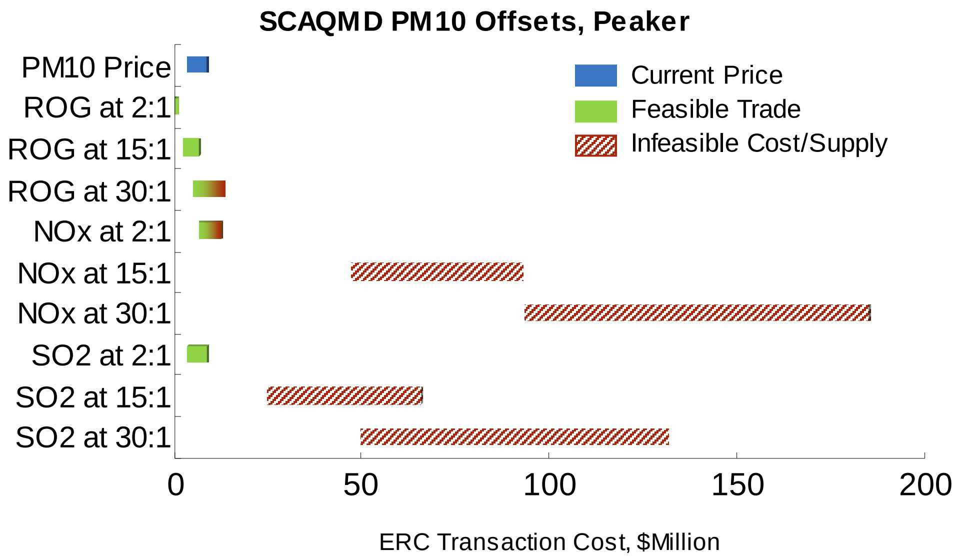
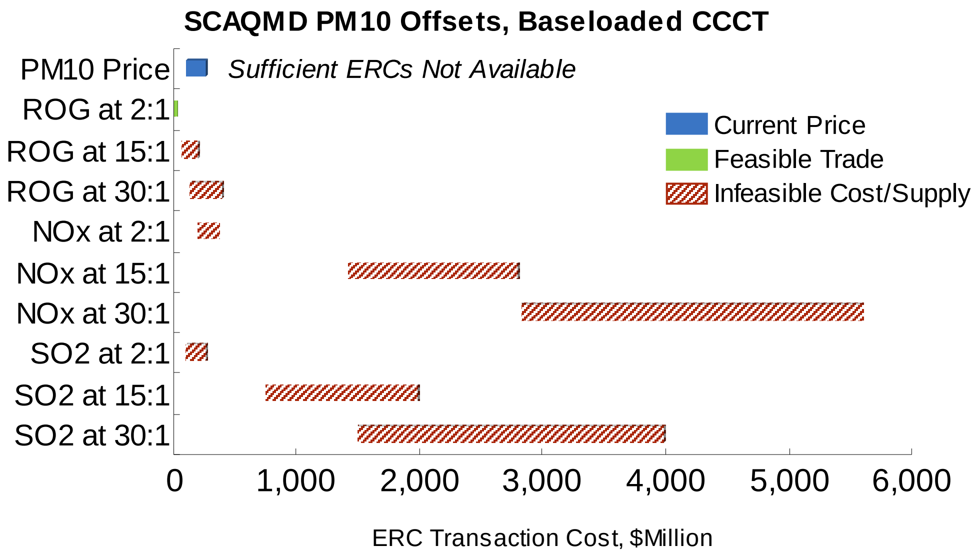


Figure 21 provides the estimated transaction prices for interpollutant trades to offset PM_{10} emissions from a SCAQMD base loaded combined-cycle power plant. The transaction cost shown for actual PM_{10} emission reduction credits is an estimate because there is insufficient supply of PM_{10} emission reduction credits for the base loaded plant; the actual market price is indeterminate. There is also insufficient supply of any of the other ERCs considered as substitutes (ROG, NOx, SO_2), except for ROG at a 2:1 ratio. There is sufficient supply of ROG at a 2:1 ratio to offset the PM_{10} emissions; the transaction cost is estimated to range from $9 to $26 million. A cautionary note is that substituting ROG emission reduction credits for PM_{10} emissions may affect ozone attainment, depending upon whether SCAMQD is in a NOx benefit or disbenefit regime at present and in the future.

Figure 21. SCAQMD Combined-Cycle Plant Interpollutant Trade Transaction Cost Estimates



Based on the information provided in this section it is reasonable to conclude that:

- the small supply and high cost of PM_{10} emission reduction credits is a factor that complicates the development of power plants in the SCAQMD, and
- A sufficient quantity of PM_{10} emission reduction credits is likely available from inside District sources to facilitate the acquisition of 4 tpy of PM_{10} emission reduction credits.

4.2.2 San Diego APCD

The San Diego APCD emission reduction credits market is less active then the SCAQMD emission reduction credits market. After reviewing the ERC bank and engaging in discussions with prospective sellers, it is the contractor's belief that the supply of NOx and VOC emission reduction credits, and associated offer prices, are as follows:

- NOx 6 tpy[22] Offered at $175,000/tpy
- VOC 32 tpy[23] Offered at $87,500/tpy

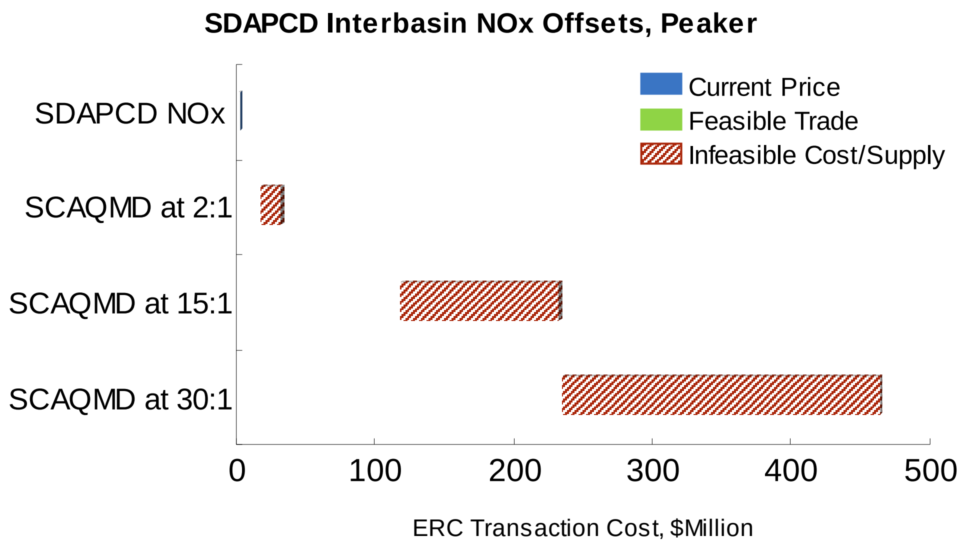
As of 2010, the contractors were not aware of any active demand for NOx and VOC ERCs. As such, there are no bids for such credits. However, a single power plant would easily exhaust the supply of NOx and VOC emission reduction credits.

[22] Approximately 170 tpy NOx ERCs are banked but not available for purchase (the owners have other plans for them).

[23] Approximately 300 tpy of VOC ERCs are banked but not available for purchase (the owners have other plans for them).

There is a sufficient NOx emission reduction credits supply (including VOC emission reduction credits at 2:1) to offset our peaker plant NOx emissions. We look to SCAQMD to see if interbasin trades would be less expensive. For the peaker, Figure 22, there is sufficient SCAQMD supply to offset NOx emissions at a 2:1 ratio in SDAPCD; however, the transaction cost is significantly higher than the San Diego-sourced ERCs. At present, there is not enough NOx emission reduction credits supply (including VOC emission reduction credits at 2:1) in San Diego to offset our base loaded plant NOx emissions. Similarly, there is not enough supply in SCAQMD to offset the base loaded plant NOx emissions. Therefore, none of the interbasin trades between SCAQMD and SDAPCD are economically feasible at present.

Figure 22. SDAPCD Peaker Plant Interbasin Trade Transaction Costs



Based on the information provided in this section, it is reasonable to conclude that:

- the small quantity and high cost of VOC and NOx emission reduction credits complicates the development of power plants in the SDAPCD, and
- an insufficient supply of credits (121 tpy NOx credits are needed) exists to permit a baseload power plant .

4.2.3 Sacramento Metropolitan AQMD

The Sacramento Metropolitan AQMD emission reduction credits market is probably less active then both the SCAQMD and San Diego APCD emission reduction credits markets. After reviewing the ERC bank and engaging in discussions with prospective sellers, it is the contractor's belief that the supply of NOx and VOC emission reduction credits, and associated offer prices, are as follows:

- NOx 3.757 tpy No offer price
- VOC 4.6955 tpy No offer price

In Sacramento, there is insufficient NOx emission reduction credits supply to provide offsets for either of our example power plants. Additionally, there is an insufficient VOC emission reduction credits supply for our base loaded power plant. Interbasin trading from the Bay Area into Sacramento is neither currently allowable nor environmentally beneficial (per the air quality modeling results). Interbasin trading from San Joaquin Valley into Sacramento was considered here. Our modeling results showed that this transaction would lead to increased emissions in Sacramento, but recall that the power plant location modeled was outside of the urban center and therefore in a slightly NOx benefit area. If the plant were located within SMAQMD, where the conditions are NOx disbenefit, then this transaction would not have an adverse impact on ozone in Sacramento. The NOx emission reduction credits results for the peaker and base loaded plants are provided in Figures 23 and 24.

Sufficient VOC emission reduction credits are available at reasonable cost for the peaker plant in SMAQMD, so interbasin trades do not improve cost. However, there are not sufficient VOC emission reduction credits for our base loaded plant—interbasin VOC trades from SJVAPCD do provide market relief and supply up to a ratio of 30:1.

Figure 23. SMAQMD Peaker Plant Interbasin NOx Trade Transaction Costs

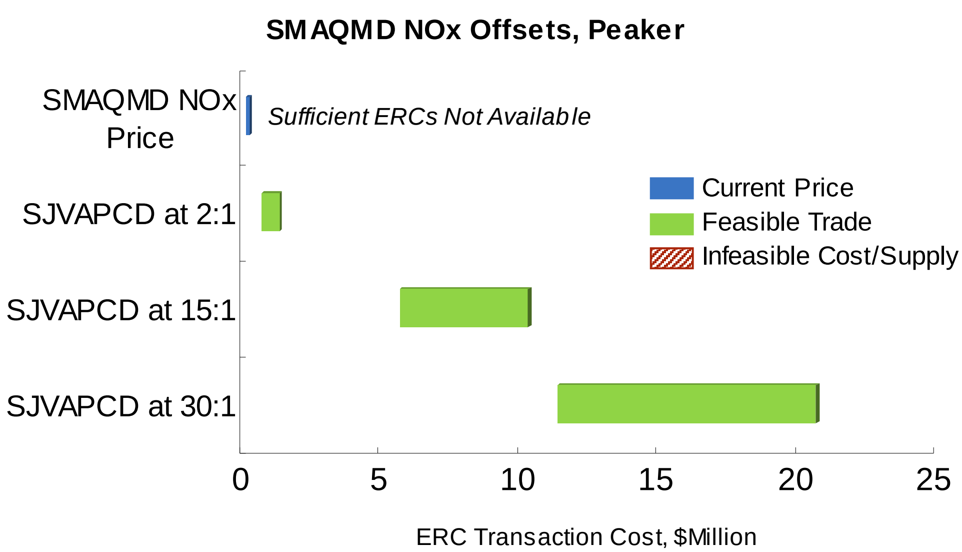
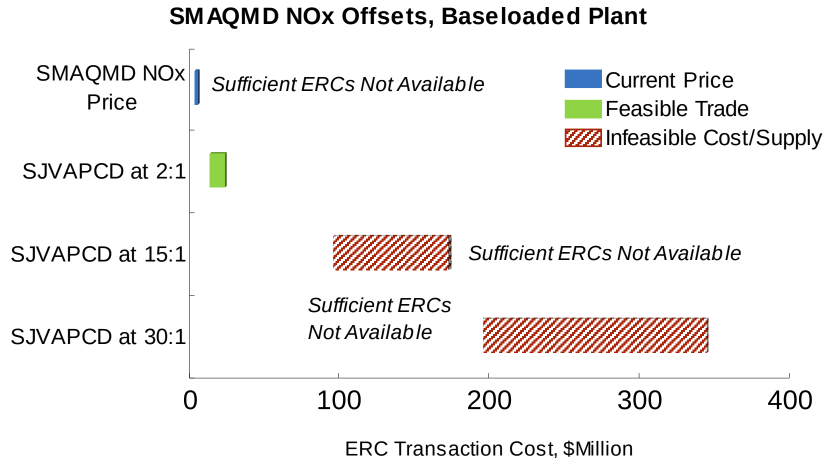


Figure 24. SMAQMD Base Loaded Plant Interbasin NOx Trade Transaction Costs



As of 2010, demand for VOCs and NOx exceed 10 tpy. A single large source (i.e., power plant) would easily exhaust the supply of VOC and NOx emission reduction credits. Based on the information provided in this section, it is reasonable to conclude that:

- the small supply and high cost of VOC and NOx is a factor that complicates the development of power plants in the Sacramento Metropolitan AQMD,
- a sufficient quantity of ERCs is likely available from inside District sources to facilitate the acquisition of 2 tpy of VOCs,
- an insufficient supply exists to permit a source requiring 31 tpy of VOC ERCs, and
- an insufficient supply exists to permit a source requiring either 10 tpy or 166 tpy NOx.

4.2.4 San Joaquin Valley APCD

The San Joaquin Valley APCD emission reduction credits market is described here solely because ERCs located therefrom could be used in inter-district trades with sources requiring ERCs in Sacramento. The San Joaquin Valley is less active than the SCAQMD but more active than either Sacramento or San Diego. After reviewing the ERC bank and engaging in discussions with prospective sellers, it is the contractor's belief that the supply of NOx and VOC ERCs, and associated offer prices, are as follows:

			Low Price	High Price
•	NOx	1,312 tpy	$38,000/tpy	$69,000/tpy
•	VOC	2,425 tpy	$12,500/tpy	$26,500/tpy

As of 2010, the demand for NOx emission reduction credits is 450 tpy, and 200 tpy for VOC emission reduction credits.

4.3 Discussion

This section provides the major conclusions regarding the potential use of flexible trading mechanisms in order to meaningfully address ERC shortfalls. Because local air districts would likely require an offset ratio greater than 1:1 for these transactions, the analysis considered a range of offset ratios for each trade: 2:1, 15:1, and 30:1. The conclusions rely heavily on the information provided in Table 22. Appendix B provides more detailed information regarding these markets and the use of selected flexible trading mechanism in each area. As a result of this analysis the authors offer the following conclusions provided below. For each area, the most pertinent pollutant is discussed.

4.3.1 South Coast AQMD

In the South Coast AQMD there are sufficient PM_{10} emission reduction credits for the smaller quantity (4 tpy). There is an insufficient quantity of PM_{10} emission reduction credits to satisfy a 121 tpy need. The application of flexible trading mechanisms provides the results noted below.

- ROG may provide a means to secure needed PM_{10}, but only for smaller volumes (4 tpy) and at lower ratios (2:1). The application of higher ratios (about, for example, 15:1 and 30:1) results in EITHER extremely high prices[24] and/or an insufficient quantity of ERCs needed for small and large projects.
- NOx RECLAIM trading credits do not provide a cost-effective means to satisfy needed PM_{10} for either the small (4 tpy) or large (121 tpy) volumes. The application of higher ratios (about 15:1 AND 30:1) results in EITHER extreme highly prices and/or an insufficient quantity of RTCs needed for small and large projects.
- SOx emission reduction credits may provide a means to secure needed PM_{10}, but only for smaller volumes (4 tpy) at lower ratio (2:1). The application of higher ratios or the larger volume results in EITHER extremely high prices and/or an insufficient quantity of ERCs needed for small and large projects.
- Owing to a lack of available information regarding actual versus permitted emissions, bubbling trading cannot be evaluated at this time.

4.3.2 San Diego APCD

In the San Diego APCD there are sufficient NOx and VOC emission reduction credits to secure 10 tpy, but not 166 tpy, of NOx ERCs. The application of flexible trading mechanisms provides the results noted below.

- Using SCAQMD NOx RECLAIM trading credits does not provide a means to cost-effectively satisfy needed NOx emission reduction credits for either the large or small projects.

---

[24] "Extremely high prices," as used in this report, means that there are sufficient quantities of credits available, but only at a cost that is MORE expensive than the option of securing the credits without the use of the flexible trading mechanism.

4.3.3 Sacramento Metropolitan AQMD

In the Sacramento Metropolitan AQMD there are insufficient NOx emission reduction credits to satisfy either the 10 or 166 tpy requirement. Relative to VOC emission reduction credits, there are sufficient ERCs to satisfy a 2 tpy demand but not a 31 tpy VOC emission reduction credits need. The application of flexible trading mechanisms provides the results noted below.

- Using San Joaquin Valley NOx emission reduction credits to satisfy a Sacramento NOx emission reduction credits need may be:
    - Feasible and cost effective for the smaller (10 tpy) plants at all ratios
    - Feasible but expensive for the larger (166 tpy) plant at a the lower ratio (~2:1)
    - Neither feasible nor cost effective for the larger need and at the higher ratios (~15:1 and 30:1)
- Using San Joaquin Valley VOC emission reduction credits to satisfy a Sacramento VOC emission reduction credits need may be:
    - Feasible but not cost effective for the smaller (2 tpy) need at both the low and high ratios (for example 2:1, 15:1, and 30:1)
    - Feasible and cost effective for the larger (31 tpy) need and at the low ratio (~2:1)
    - Feasible but expensive for the larger (31 tpy) need at higher ratios (~15:1 and 30:1)

Table 25 provides a summary of the market analysis results for the three regions. Interpollutant offsets for SCAQMD PM_{10} may provide some relief to the PM_{10} market constraints if low offset ratios are allowed. Interbasin trades from SJVAPCD to Sacramento may provide some price relief to the NOx and VOC markets. While short-term trading would clearly be helpful to power plant developers, it was not possible to quantity the availability of short-term ERCs within the budget constraints of the project. The difficulty in obtaining these data is likely one of the reasons short-term trades are rarely executed.

Table 25. Summary of Market Analysis Results

Offset Emissions	ERC Source	Peaker Plant	Base Loaded Plant
SCAQMD PM_{10}	SCAQMD ROG	Feasible at ratios < 15:1	Feasible at 2:1 ratio, above this supply of ROG depletes
SCAQMD PM_{10}	SCAQMD NOx	Not feasible (price)	Not feasible (supply)
SCAQMD PM_{10}	SCAQMD SO2	Feasible at 2:1 ratio	Not feasible (supply)
SDAPCD NOx	SCAQMD NOx	Not feasible (price)	Not feasible (supply)
SMAQMD NOx	SJVAPCD NOx	Feasible up to 30:1 ratio	Feasible at 2:1 ratio then supply depletes
SMAQMD VOC	SJVAPCD VOC	Not Feasible (price)	Feasible up to 2:1 ratio

CHAPTER 5:
Conclusions and Recommendations

This study has shown that more flexible trading mechanisms, such as interpollutant and interbasin trades, can provide power plants access to ERCs that were unavailable and/or can reduce ERC prices. The study focused on three districts that have insufficient ERCs available at present to allow installation of a new base loaded power plant. More flexible interbasin and interpollutant trading was considered to alleviate the constrained ERC markets in two of them. For SCAQMD, an extreme shortage of PM_{10} emission reduction credits could be alleviated somewhat with interpollutant trading of ROG and SO_2. Neither of these trades is currently done. For Sacramento, it was shown that interbasin trades from San Joaquin Valley could alleviate NOx and VOC shortages. Whether these trades adversely impact air quality in either region would depend upon whether the power plant location and the ERC source location are NOx benefit or NOx disbenefit regions.

It appears that a significant burden is placed on project developers in the three districts that require ambient modeling. This burden deters interpollutant trading. In different districts, the various interpollutant ratios or prohibition of interpollutant trades may be predicated on indications that VOC emissions in some areas have a greater or lesser impact on ozone formation. From an ERC market perspective, it would likely be beneficial if a state agency could periodically perform modeling for each air district and provide technically sound guidelines on interpollutant trades (including ratios) that reflect the relative merits of reducing NOx or VOC in a given geographic region. Theoretically, explicit rules based on science would enhance ERC markets.

The impact of NOx interbasin trading between the SF Bay Area, San Joaquin Valley, and Sacramento air basins on ozone formation was evaluated as part of this project, using an air quality model executed by LBNL. Three key findings were noted:

1. For the scenarios modeled, there were no conventional allowable trades found where removed emissions mitigated to any extent ozone at the location where emissions were added. Instead, the emissions from the new power plants had no measurable impact on downwind ozone formation (in adjacent air basins), even when the power plant emissions were multiplied by a factor of ten. In other words, even when the meteorology was favorable for the trade, as defined by an *overwhelmingly* impacted area, there were no instances when the change in emissions affected ozone formation downwind at the new power plant location.

2. There were several instances where an ozone-neutral or beneficial trade was modeled, but this was due to the different chemistry at different areas, not due to the mitigating nature of removing emissions upwind. The ozone-neutral trades occur when the new power plant is located in a NOx disbenefit area (where adding NOx reduces ozone) and the ERCs must come from a NOx benefit area. However, it is useful to point out that the chemistry changes over time, and therefore it is difficult to assess over the long term whether a NOx benefit or disbenefit area will remain that way. Additionally, adding

NOx may reduce ozone locally but most likely will have negative impacts on NO_2 and PM levels, and can increase ozone further downwind. For these reasons, regulators do not normally consider adding NOx emissions to a NOx disbenefit area to be a viable control strategy.

3. The modeled ozone changes and direction of changes are extremely sensitive to the emissions inputs for the regions in California modeled here. Given the uncertainty in the current inventory, and the need to accurately predict *future* inventories in order to assess the viability of a long-term trade, it is unlikely that modeling can conclusively determine the benign nature of these potential trades. Moreover, the resolution of the model was not sensitive enough to detect impacts from the magnitude of typical trades. However, the meteorological data and computational approach do exist and have been used to successfully demonstrate the ability to model how impacts would occur over days, seasons, or years into the future.

The air quality modeling was intended as an exploratory exercise. As such, these results and conclusions are preliminary. In general we conclude that more flexible interbasin NOx trading is feasible. However there are several caveats: there can be local impacts of the power plants, secondary PM_{10} emissions must be considered, and future NOx and VOC levels should be considered. Clearly, the conservative trading ratio approach used today is a result of these complex factors and uncertainties, as seen in this modeling exercise, demonstrating that these factors have not become any more certain with the improved modeling techniques.

If further investigation were to be pursued, it is recommended that additional modeling be conducted using a more recent ozone episode and updated emissions data to reflect near-term reductions in the heavy-duty vehicle fleet emissions. It is also recommended that the modeling domain be extended to include Southern California – particularly the interactions of Ventura, Los Angeles, eastern Kern and San Diego counties, and the eastern Los Angeles air districts. Finally, in addition to NOx, the impacts of VOC and PM_{10} (including secondary formation from NOx, VOC, and SO_2) be evaluated. The main purpose of the recommended study would be to verify the findings discussed above, to extend the analysis to the rest of the state's nonattainment areas, and to evaluate the impacts of interbasin trading on secondary PM_{10} formation.

If the recommended follow-on ozone and PM_{10} modeling is conducted and shows that the federal and state restrictions on interbasin trades could be modified while still protecting ambient air quality, then conceivably ERCs from non-adjacent air basins could be traded freely. Further assuming that rules governing the use of ERCs were modified based on the modeling results, ERC supplies in currently constrained markets would be significantly augmented. More ERC availability results in lower prices which will facilitate installation of new, clean power generation in the State of California.

References

ARB. 1990. New Source Review Workshop Manual: Prevention of Significant Deterioration and Nonattainment Area Permitting. California Air Resources Board. October 1990 DRAFT.

ARB. 1996. *Guidelines for the Generation and Use of Mobile Source Emission Reduction Credits.* February. http://www.arb.ca.gov/msprog/mserc/mscguide.pdf.

ARB. 1997. Credit Interchangeability Rule. Interchangeable Air Pollution Emission Reduction Credits, section 91500 through 91508 of Subchapter 5.6, Chapter 1, Division 3, Title 17, California Code of Regulations. http://www.arb.ca.gov/regact/ierc/finreg.pdf.

ARB. 1999. *Guidance for Power Plant Siting and Best Available Control Technology.* September. http://www.arb.ca.gov/energy/powerpl/guidocfi.pdf.

ARB. 2001. *Assessment and Mitigation of the Impacts of Transported Pollutants on Ozone Concentrations in California.* http://www.arb.ca.gov/regact/trans01/isor.pdf.

ARB. 2003. *Initial Statement of Reasons for the Proposed Amendments to the Ozone Transport Mitigation Regulations.* Air Resources Board Staff Report, April 4, 2003.

ARB. 2009. Emission Projections by Summary Category. Base year 2008. http://www.arb.ca.gov/app/emsinv/fcemssumcat2009.php.

CAA Title I, Part D, SubPart 1: Nonattainment Areas in General and SubPart 2: Additional Provisions for Ozone Nonattainment Areas

Harley, Robert A., Nancy J. Brown, Shaheen R. Tonse, and Ling Jin. 2006. *A Seasonal Perspective on Regional Air Quality in Central California.* http://escholarship.org/uc/item/9q75j9kf.

South Coast Air Quality Management District (SCAQMD). 2010. *Rule 214 – Federal New Source Review, Adopted 10-28-10***.** Accessed on September 20, 2012. http://www.airquality.org/notices/Rules2012/20120606Rules214Workshop.pdf.

Title 17 California Code of Regulation, Sections 91500–91508, 1997.

U.S. EPA. December 1993. NOx Substitution Guidance. Office of Air Quality Planning and Standards. http://www.epa.gov/ttn/oarpg/t1/memoranda/noxsubst.pdf.

U.S. EPA. 1995. Open Market Trading Rule for Ozone Smog Precursors.

http://www.gpo.gov/fdsys/pkg/FR-1995-08-25/pdf/95-21168.pdf.

Glossary

APCD	San Diego Air Pollution Control District
ARB	California Air Resources Board
BAAQMD	Bay Area Air Quality Management District
BACT	Best Available Control Technology
CAA	Federal Clean Air Act
CCCT	combined-cycle natural-gas-fired combustion turbine
CCOS	Central California Ozone Study
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulation
CMAQ	Community Multiscale Air Quality Model
CO	carbon monoxide
DER	discrete emission reductions
ERC	emission reduction credits
GHG	greenhouse gas
GW	Gigawatts
GWh	gigawatt-hours
H&S	Health and Safety
ISOR	Initial Statement of Reasons
LAER	lowest achievable emission rate
LBNL	Lawrence Berkeley National Laboratory
MSERC	Mobile Source Emission Reduction Credits
MW	Megawatt
NAAQS	national ambient air quality standards
NA	not applicable
ND	not detectable
NGO	non-governmental organization

NO_2	nitrogen dioxide
NO_x	nitrogen oxides
NRDC	National Resources Defense Council
NSR	New Source Review
O_3	ozone
OR	offset ratio
PDT	Pacific Daylight Time
PM	particulate matter
ppb	part per billion
RAQS	Regional Air Quality Strategy
ROG	reactive organic gas
RTC	RECLAIM Trading Credit
SAC	Sacramento
SAAQS	state ambient air quality standards
SCAQMD	South Coast Air Quality Management District
SCCT	simple-cycle natural-gas-fired combustion turbine
SFB	San Francisco Bay
SDAPCD	San Diego Air Pollution Control District
SIP	State Implementation Plan
SJV	San Joaquin Valley
SJVAPCD	San Joaquin Valley Air Pollution Control District
SMAQMD	Sacramento Metropolitan Air Quality Management District
SO_2	sulfur dioxide
STC	short-term credits
tpy	tons per year
U.S. EPA	U.S. Environmental Protection Agency
VOC	volatile organic compounds

APPENDIX A:
Emissions by Source Categories, Days of Week and Subregions, and Ozone Sensitivity

Table A-1. Emission Rates by Source Category, Day of Week and Subregion, in Metric Tons Per Day

Emission Rate (tons/day)		Whole Domain				San Francisco Bay Area				San Joaquin Valley				Sacramento Valley			
		Mon*	Fri	Sat	Sun	Mon*	Fri	Sat	Sun	Mon*	Fri	Sat	Sun	Mon*	Fri	Sat	Sun
Base Case NOx	Motor	609	681	489	429	184	204	150	129	176	191	125	107	82	95	72	65
	Area	621	621	519	519	134	134	107	107	197	197	152	152	91	91	75	75
	Point	180	180	160	155	60	60	56	53	33	33	29	28	14	14	13	13
Added Point NOx	Peaker**	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0	0	0	0	0	0	0	0
	Base Load**	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	0	0	0	0	0	0	0	0
Base Case VOC	Motor	607	645	569	527	216	223	196	178	134	145	123	120	90	93	81	77
	Area	1232	1232	1445	1445	236	236	253	253	411	411	429	429	169	169	199	199
	Point	116	116	81	77	69	69	46	42	18	18	14	14	7	7	5	4
Added Point VOC	Peaker**	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0	0	0	0	0	0	0	0
	Base Load**	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0	0	0	0	0	0	0	0
CO	Motor	5953	6374	5640	5261	2095	2180	1922	1741	1230	1330	1140	1127	848	903	792	753
	Area	2695	2695	4317	4317	482	482	813	813	496	496	687	687	436	436	707	707
	Point	462	462	215	215	252	252	38	33	25	25	22	21	35	35	32	31

*Monday is representative of Monday to Thursday.
** Indicates 10 plants.

Table A-2. Location and Status of Power Plants (Operating and Pending) Used for Air Quality Modeling Analysis Selections

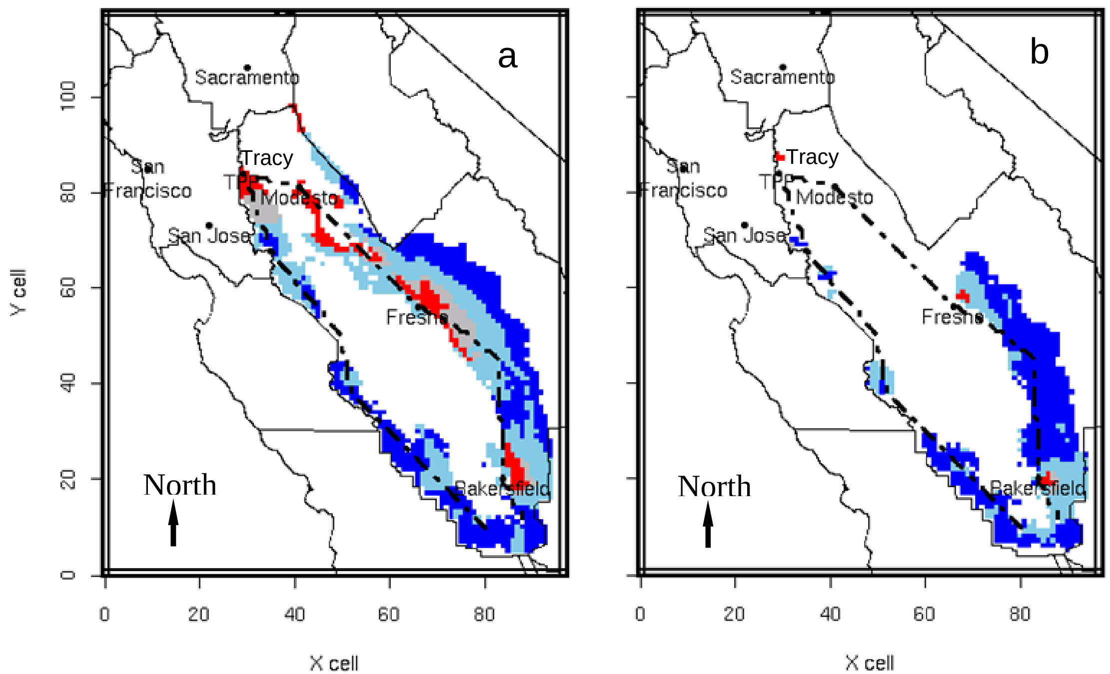
	Name	City	Coordinates (x , y) *	Type	Size (MW)	Emission Factor	Status	Scaled Potential Local Impact ***
SF Bay Area								
	SF Reliability Peakers	San Francisco	(54, 94)	Peakers	145	1.0	pending	Negative
	Marsh Landing	Contra Costa	(66, 102)	Peakers	930	6.2	operating	
	Russell City	Alameda	(61, 92)	Base	600	1.2	pending	Negative
	Willow Pass	Contra Costa	(65, 102)	Base	550	1.1	operating	
	Eastshore Energy	Contra Costa or Alameda	(62, 92)	Base	118	0.2	operating	
	Los Esteros	Santa Clara	(63, 86)	Base	140	0.3	pending	Negative
	FPL Tesla	Alameda	(72, 93)	Base	1120	2.2	pending	Negative
SJ Valley								
	GWF Tracy	San Joaquin	(74, 93)	Peakers	314	2.1	operating	
	Panoche Energy Center	Fresno	(92, 65)	Peakers	400	2.7	pending	~ 0.3 ppb
	Starwood Midway Panoche	Fresno	(94, 65)	Peakers	120	0.8	pending	~ 0.1 ppb
	Bullard Energy Center	Fresno	(109, 69)	Peakers	200	1.3	pending	~ 0.1 ppb
	Community Power	Fresno	(110, 63)	Base	565	1.1	operating	
	Avenal Energy	Kings	(104, 49)	Base	600	1.2	operating	
	Walnut Energy	Stanislaus	(86, 87)	Base	250	0.5	operating	
	Central Valley Energy	Fresno	(102, 62)	Base	1087	2.2	pending	~ 0.7 ppb
	Pastoria	Kern	(135, 21)	Base	160	0.3	pending	~ 0.1 ppb
Sacramento								
	Roseville Energy Park	Placer	(77, 122)	Base	160	0.3	operating	
	SMUD Cosumnes River	Sacramento	(81, 111)	Base	500	1.0	operating	
	Colusa Generating	Colusa	(58, 140)	Base	660	1.3	pending	~0.5 ppb

* from conversion of latitude and longitude of the site location, Google Map and PAVE

** according to emission_rate_calcs file data

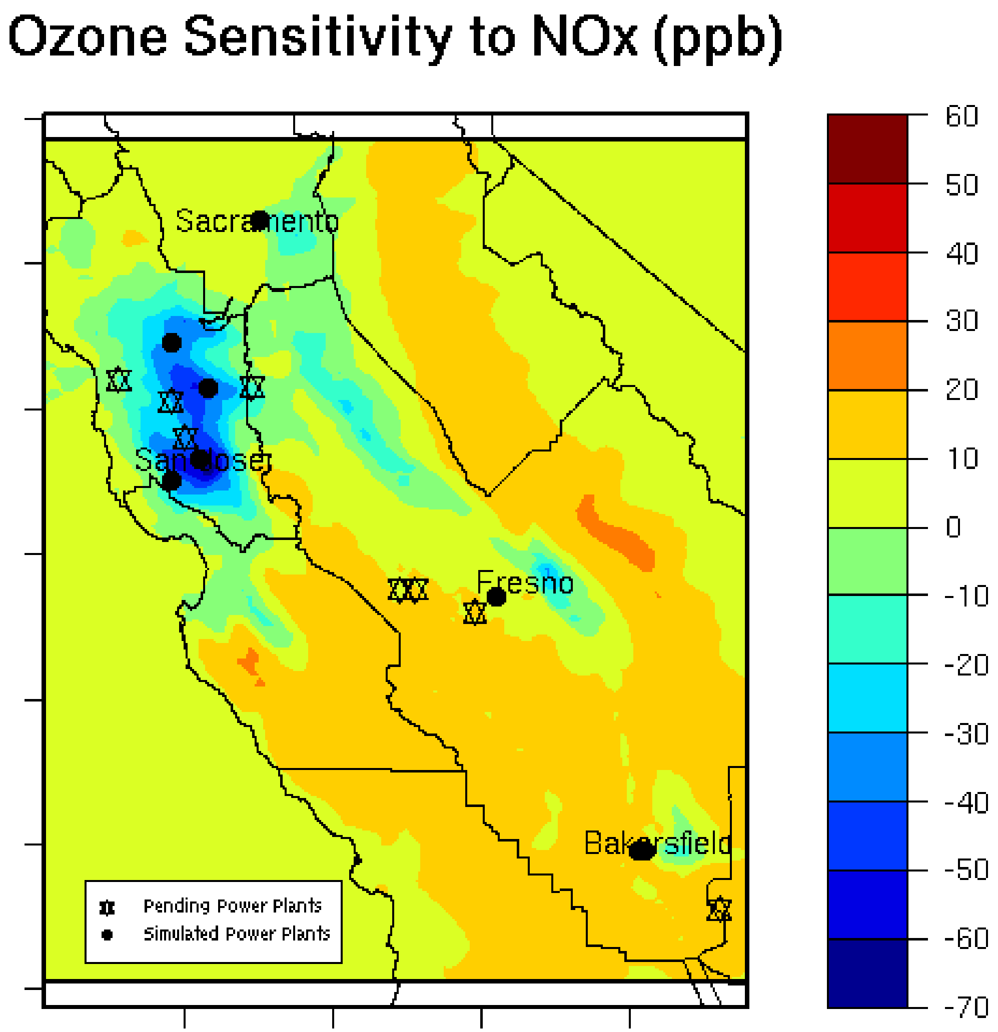
*** maximum ozone difference (ppb) at the source at 3:00 p.m.

Figure A-1 Mapping of Ozone Sensitivity Options at 8-hr Peak Ozone Exceedances in the SJV for Year 2000 Emissions



a. weekdays, b. weekends. Locations always in "VOC control" are coded in red; NOx control always beneficial ($\frac{\partial[O_3]}{\partial\varepsilon_{E_{NO_x}}} > 0$) in light blue, among which, the locations that are always in "NOx control" option ($\frac{\partial[O_3]}{\partial\varepsilon_{E_{NO_x}}} > \frac{\partial[O_3]}{\partial\varepsilon_{E_{AVOC}}}$) are further coded in blue; and finally, a mixed regime ($\frac{\partial[O_3]}{\partial\varepsilon_{E_{NO_x}}}$ changes signs) in grey. The non-exceedance areas in SJV are marked in white.

Figure A-2. Ozone Sensitivity to NO_x with Locations of Pending and Simulated Power Plants



APPENDIX B:
Emission Reduction Credit Markets and Trading Mechanisms

South Coast AQMD								
PM_{10} ERCs								
	Total Supply (lb/day)	**Total Supply (tpy)**	**Total Demand (lb/day)**	**Total Demand (tpy)**	**Price (lb/day) LOW**	**Price (lb/day) HIGH**	**Price (tpy) LOW**	**Price (tpy) HIGH**
PM_{10} ERCs	248	45.26	1,000	182.50	$150,000	$400,000	$821,918	$2,191,781
					Minimum need – 4 tpy PM_{10}		**Maximum need – 121 tpy PM_{10}**	
					Low	**High**	**Low**	**High**
					$3,287,671	$8,767,123	$99,452,055	$265,205,479

Converting SOx ERCs to PM_{10} ERCs								
	Total Supply (lb/day)	**Total Supply (tpy)**	**Total Demand (lb/day)**	**Total Demand (tpy)**	**Price (lb/day) LOW**	**Price (lb/day) HIGH**	**Price (tpy) LOW**	**Price (tpy) HIGH**
SOx ERCs	347	63.33	1,000	182.50	$75,000	$200,000	$410,959	$1,095,890
Convert SOx ERCs to PM_{10} ERCs based on possible ratios (# SOx : 1 PM_{10})								

Converting SOx ERCs to PM_{10} ERCs								
	Total Supply (lb/day)	**Total Supply (tpy)**	**Total Demand (lb/day)**	**Total Demand (tpy)**	**Price (lb/day) LOW**	**Price (lb/day) HIGH**	**Price (tpy) LOW**	**Price (tpy) HIGH**
					Minimum need – 4 tpy PM_{10}		**Maximum need – 121 tpy PM_{10}**	
	Ratio	**PM_{10} tpy**			**Low**	**High**	**Low**	**High**
	2:1	31.66			$3,287,671	$8,767,123	$99,452,055	$265,205,479
	15:1	4.22			$24,657,534	$65,753,425	$745,890,411	$1,989,041,096
	30:1	2.11			$49,315,068	$131,506,849	$1,491,780,822	$3,978,082,192

Key	
Feasible Supply and Cost	Insufficient Supply
Feasible Supply but not Cost	Unknown

Converting ROG ERCs to PM_{10} ERCs								
	Total Supply (lb/day)	Total Supply (tpy)	Total Demand (lb/day)	Total Demand (tpy)	Price (lb/day) LOW	Price (lb/day) HIGH	Price (tpy) LOW	Price (tpy) HIGH
ROG ERCs	4,000	730	1,500	273.75	$7,000	$20,000	$38,356	$109,589
Convert ROG ERCs to PM_{10} ERCs based on possible ratios (# ROG : 1 PM_{10})								
					Minimum need – 4 tpy PM_{10}		Maximum need – 121 tpy PM_{10}	
	Ratio	PM_{10} tpy			Low	High	Low	High
	2:1	365.00			$306,849	$876,712	$9,282,192	$26,520,548
	15:1	48.67			$2,301,370	$6,575,342	$69,616,438	$198,904,110
	30:1	24.33			$4,602,740	$13,150,685	$139,232,877	$397,808,219

Converting NOx RTCs to PM_{10} ERCs										
	NOx RTC Total Supply (lb/day)	NOx ERC* (lb/day)	NOx RTC Total Demand (lb/day)	NOx ERC* Total Demand (lb/day)	NOx RTC Price (lb/day) LOW	NOx RTC Price (lb/day) HIGH	NOx ERC Price (lb/day) LOW	NOx ERC Price (lb/day) HIGH	NOx ERC Price (tpy) LOW	NOx ERC Price (tpy) HIGH
NOx RTCs converting to NOx ERCs	950,000	368.125	600,000	232.50	$55	$109	$141,935.48	$281,290.32	$777,729	$1,541,317

Converting NOx RTCs to PM_{10} ERCs										
	NOx RTC Total Supply (lb/day)	NOx ERC* (lb/day)	NOx RTC Total Demand (lb/day)	NOx ERC* Total Demand (lb/day)	NOx RTC Price (lb/day) LOW	NOx RTC Price (lb/day) HIGH	NOx ERC Price (lb/day) LOW	NOx ERC Price (lb/day) HIGH	NOx ERC Price (tpy) LOW	NOx ERC Price (tpy) HIGH

Convert NOx ERCs to PM_{10} ERCs based on possible ratios (# NOx ERCs : 1 PM_{10})								
					Minimum need – 4 tpy PM_{10}		Maximum need – 121 tpy PM_{10}	
	Ratio	PM_{10} tpy			Low	High	Low	High
	2:1	33.59			$6,221,829	$12,330,535	$188,210,340	$372,998,674
	15:1	4.48			$46,663,721	$92,479,010	$1,411,577,552	$2,797,490,057
	30:1	2.24			$93,327,441	$184,958,020	$2,823,155,104	$5,594,980,115

*NOx RTC converted to NOx ERC - (RTC x 0.775)/2000

Key	
Feasible Supply and Cost	Insufficient Supply
Feasible Supply but not Cost	Unknown

San Diego APCD					
SDAPCD NOx ERCs					
	Total Supply (tpy)	**Total Demand (tpy)**		**Price (tpy) LOW**	**Price (tpy) HIGH**
NOx ERCs	6.0	0.0		$160,000	$175,000
	Minimum need – 10 tpy NOx			**Maximum need – 166 tpy NOx**	
	Low	**High**		**Low**	**High**
	$1,600,000	$1,750,000		$26,560,000	$29,050,000

Key	
Feasible Supply and Cost	Insufficient Supply
Feasible Supply but not Cost	Unknown

Converting South Coast NOx RTCs to SDAPCD NOx ERCs										
	NOx RTC Total Supply (lb/day)	**NOx ERC* (lb/day)**	**NOx RTC Total Demand (lb/day)**	**NOx ERC* Total Demand (lb/day)**	**NOx RTC Price (lb/day) LOW**	**NOx RTC Price (lb/day) HIGH**	**NOx ERC Price (lb/day) LOW**	**NOx ERC Price (lb/day) HIGH**	**NOx ERC Price (tpy) LOW**	**NOx ERC Price (tpy) HIGH**
South Coast NOx RTCs converting to SDAPCD NOx ERCs	950,000	368.125	600,000	232.50	$55	$109	$141,935.48	$281,290.32	$777,729	$1,541,317

Converting South Coast NOx RTCs to SDAPCD NOx ERCs										
	NOx RTC Total Supply (lb/day)	NOx ERC* (lb/day)	NOx RTC Total Demand (lb/day)	NOx ERC* Total Demand (lb/day)	NOx RTC Price (lb/day) LOW	NOx RTC Price (lb/day) HIGH	NOx ERC Price (lb/day) LOW	NOx ERC Price (lb/day) HIGH	NOx ERC Price (tpy) LOW	NOx ERC Price (tpy) HIGH

Convert South Coast NOx ERCs to SDAPCD NOx ERCs based on possible ratios (# South Coast NOx ERCs : 1 SDAPCD NOx ERC)								
					Minimum need – 10 tpy NOx		Maximum need – 166 tpy NOx	
		Ratio	NOx ERC tpy		Low	High	Low	High
		2:1	33.59		$15,554,574	$30,826,337	$258,205,921	$511,717,190
		15:1	4.48		$116,659,302	$231,197,525	$1,936,544,410	$3,837,878,922
		30:1	2.24		$233,318,604	$462,395,051	$3,873,088,820	$7,675,757,844

*South Coast NOx RTC converted to SDAPCD NOx ERC - (RTC x 0.775)/2000

Converting SDAPCD VOC ERCs to SDAPCD NOx ERCs					
	Total Supply (tpy)	**Total Demand (tpy)**		**Price (tpy) LOW**	**Price (tpy) HIGH**
VOC ERCs	32	0.00		$70,000	$87,500

Convert SDAPCD VOC ERCs to SDAPCD NOx ERCs based on possible ratios (# VOC : 1 NOx)					
		Minimum need – 10 tpy NOx		**Maximum need – 166 tpy NOx**	
Ratio	**NOx tpy**	**Low**	**High**	**Low**	**High**
2:1	16.10	$1,400,000	$1,750,000	$23,240,000	$29,050,000
15:1	2.15	$10,500,000	$13,125,000	$174,300,000	$217,875,000
30:1	1.07	$21,000,000	$26,250,000	$348,600,000	$435,750,000

San Diego APCD
SDAPCD VOC ERCs

	Total Supply (tpy)	Total Demand (tpy)		Price (tpy) LOW	Price (tpy) HIGH
VOC ERCs	32.0	0.0		$70,000	$87,500
	Minimum need – 2 tpy NOx			**Maximum need – 31 tpy NOx**	
	Low	**High**		**Low**	**High**
	$140,000	$175,000		$2,170,000	$2,712,500

Key	
Feasible Supply and Cost	Insufficient Supply
Feasible Supply but not Cost	Unknown

Converting South Coast ROG ERCs to SDAPCD VOC ERCs								
	Total Supply (lb/day)	**Total Supply (tpy)**	**Total Demand (lb/day)**	**Total Demand (tpy)**	**Price (lb/day) LOW**	**Price (lb/day) HIGH**	**Price (tpy) LOW**	**Price (tpy) HIGH**
ROG ERCs	4,000	730	1,500	273.75	$7,000	$20,000	$38,356	$109,589
Convert South Coast ROG ERCs to SDAPCD VOC ERCs based on possible ratios (# ROG : 1 VOC)								
		Minimum need – 2 tpy NOx		**Maximum need – 31 tpy NOx**				

Ratio	NOx tpy	Low	High	Low	High
2:1	365.00	$153,425	$438,356	$2,378,082	$6,794,521
15:1	48.67	$1,150,685	$3,287,671	$17,835,616	$50,958,904
30:1	24.33	$2,301,370	$6,575,342	$35,671,233	$101,917,808

Key	
Feasible Supply and Cost	Insufficient Supply
Feasible Supply but not Cost	Unknown

Sacramento Metropolitan AQMD

Sacramento Metropolitan AQMD NOx ERCs					
	Total Supply (tpy)	**Total Demand (tpy)**		**Price (tpy) LOW**	**Price (tpy) HIGH**
NOx ERCs	3.7	>10		$16,000	$29,000
	Minimum need – 10 tpy NOx			**Maximum need – 166 tpy NOx**	
	Low	**High**		**Low**	**High**
	$160,000	$290,000		$2,656,000	$4,814,000

Converting SJVAPCD NOx ERCs to Sacramento Metropolitan AQMD NOx ERCs					
	Total Supply (tpy)	**Total Demand (tpy)**		**Price (tpy) LOW**	**Price (tpy) HIGH**
NOx ERCs	1,312	450		$38,000	$69,000
Convert SJVAPCD NOx ERCs to Sacramento Metropolitan AQMD NOx ERCs based on possible ratios (# SJVAPCD NOx : 1 NOx)					
		Minimum need – 10 tpy NOx		**Maximum need – 166 tpy NOx**	
Ratio	**NOx tpy**	**Low**	**High**	**Low**	**High**
2:1	656.00	$760,000	$1,380,000	$12,616,000	$22,908,000
15:1	87.47	$5,700,000	$10,350,000	$94,620,000	$171,810,000
30:1	43.73	$11,400,000	$20,700,000	$189,240,000	$343,620,000

Key	
Feasible Supply and Cost	Insufficient Supply

Feasible Supply but not Cost	Unknown

Sacramento Metropolitan Air Quality Management District					
Sacramento Metropolitan AQMD VOC ERCs					
	Total Supply (tpy)	**Total Demand (tpy)**		**Price (tpy) LOW**	**Price (tpy) HIGH**
VOC ERCs	4.6	>10		$9,000	$25,000
	Minimum need – 2 tpy NOx			**Maximum need – 31 tpy NOx**	
	Low	**High**		**Low**	**High**
	$18,000	$50,000		$279,000	$775,000

Converting SJVAPCD VOC ERCs to Sacramento Metropolitan AQMD VOC ERCs						
	Total Supply (tpy)	**Total Demand (tpy)**		**Price (tpy) LOW**		**Price (tpy) HIGH**
VOC ERCs	2,425	200		$12,500		$26,500
Convert SJVAPCD VOC ERCs to Sacramento Metropolitan AQMD VOC ERCs based on possible ratios (# SJVAPCD VOC : 1 VOC)						
		Minimum need – 2 tpy VOC		**Maximum need – 31 tpy VOC**		
Ratio	**VOC tpy**	**Low**	**High**	**Low**	**High**	
2:1	1,212.50	$50,000	$106,000	$775,000	$1,643,000	
15:1	161.67	$375,000	$795,000	$5,812,500	$12,322,500	
30:1	80.83	$750,000	$1,590,000	$11,625,000	$24,645,000	

Key	
Feasible Supply and Cost	Insufficient Supply
Feasible Supply but not Cost	Unknown